CLARK'S WEAVE ROOM CALCULATIONS

BY W. A. GRAHAM CLARK

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Weave Room Calculations

A practical treatise of cotton yarn
and cloth calculations for the
weave room, especially
applicable to
Southern
Mills

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PREFACE.

This book is intended primarily for use in the mill, as an aid to those who have to make calculations dealing with cotton cloth. It can also be used as a text book.

There is apparently a need for a work of this character as there have been few books dealing with weave room calculations from the practical standpoint and most of these are out of print.

The first part of this study contains concise rules for making cloth calculations and these have been grouped to facilitate use. The cloths used to illustrate the working out of the rules are mainly staple plain fabrics such as occur most largely in actual practice. One of the most original features is that dealing with the ascertainment of the contraction in length of warp and filling yarns in the weaving of plain fabrics; in addition to rules there has been compiled a table that shows the contraction percentages for a wide range of combinations of yarn counts and spacings and this is illustrated graphically. Attention is called to this particularly because most textile books gloss over this vital phase by intimating that it is impossible to formulate practical rules for ascertaining the contraction in length of yarns during weaving.

The second part of this book lists over one thousand typical American cloths and shows full particulars including the counts of yarn used in each case. These cloths have been carefully selected and arranged and this tabulation should prove of value alike to cloth manufacturers, cloth dealers, and textile students.

A short chapter is added to show the systems used in numbering yarns of different materials, and to bring out salient facts as to materials of interest to the cotton weaver. The leading textile industries are becoming more and more interdependent and silk and artificial silk are now so largely used in cotton mills that the information given as to these materials should prove pertinent.

In the appendix are to be found tables of the usual weights and measures, also metric conversions for those interested in export trade.

W. A. GRAHAM CLARK.

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INTRODUCTION

In cloth calculations the basic factors are the yarns and their spacing, in other words the warp counts, the filling counts, the sley, and the pick. The other factors are all based on these. Every factor is part of a mathematical equation so that no factor can be changed without involving a change in one or more other factors in order to make the equation balance. The problem is to define the nature of the relationship between various factors so that in cloth calculations any unknown factor may be readily ascertained from its relationship to known factors.

The study of cloth calculations and the use of the most concise rules would be much aided if each factor had a standard symbol; for instance there is a saving of both time and space in using the letter "T" instead of writing out "total threads per square inch" or "the sum of the sley and pick." It would be well if the cotton trade and industry would adopt uniform symbols for the main factors that occur in cloth calculations. Where possible these should be, for convenience in remembering, the first letter of the factor referred to and the following are those most largely used:

Let A = Average yarn count.
W = Warp yarn count.
F = Filling yarn count.
E = Ends per inch in cloth.
P = Picks per inch.
T = Total threads per square inch (= E + P)
B = Breadth or width of cloth.
Y = Yards per pound.

Z = Ounces per yard.
S = Square yards per pound.
R = Reed, in dents per inch.
C = Cloth Constant that allows for contraction in warp and in filling and for sizing on warp.

The most important cloth calculation equation is AC = BYT. This equation is a basis for ascertaining various factors and will be discussed in detail later on.

Cloth calculations are also sometimes facilitated by the use of certain constant numbers. For instance in calculations involving 7000 (grains in a pound) and 840 (yards in a hank), the constant 8.33 can be substituted if the 7000 is divided by the 840, or the constant .12 can be substituted if the 840 is divided by the 7000. Similarly .2314 can be substituted for 7000 divided by 36×840, or 4.32 can be substituted for 36×840 divided by 7000. In simple equations, however, it is often quicker to cancel numbers common to both dividend and divisor rather than to substitute decimal numbers.

A "cloth constant" is used to compensate for contraction in width and length and for sizing on warp. It is, however, constant only for the particular set of conditions stated and in the following pages the method of ascertaining it for any known set of conditions is fully stated.

A description of a cloth involves stating the weave, the width, the ends per inch, the picks per inch, the warp yarn, the filling yarn, and the weight. For instance a full description of the cloth that is most typical of the American cotton industry today would be: A 38½ inch, 64×60,

30s.40s, 5.35-yard print cloth. This description gives every essential particular. In commercial quotations the yarn counts are usually omitted and different mills will use slightly different yarn counts, and slightly different percentages of sizing on the warp, to get the same result.

The number of warp threads or "ends" in the cloth is known as the sley, whereas the number of filling threads per inch in the cloth is known as the pick. The term "cloth construction" usually refers to the ends and picks in a square inch of cloth, thus the construction of the print cloth above is 64 $\times$ 60. In stating the construction the sley is always given first and the pick second, the 64 in this case therefore referring to the ends of warp per inch and the 60 to the picks of filling per inch. Similarly in giving yarn counts, say 30s. 40s, the warp yarn count is stated first and the filling yarn count second.

CLOTH CONTRACTION

The width of the woven cloth is less than the width of the warp in the reed. The length of the woven cloth is less than the length of the warp from the slasher. The contraction (also called shrinkage or take-up) in width and in length is affected by several factors but as it is due to the necessity of the two sets of interweaving threads bending out of their course to pass around each other it depends primarily on the spacing of the yarns and on their diameters. The subject of contraction, which merits more attention than is usually given to it, may be clarified by stating certain known facts in regard thereto.

The spacing of the interlacings is, in ordinary

cloths, a more important factor than the diameter of the yarn counts, that is, an increase of one pick per inch will normally increase the warp contraction more than heavying the warp or filling yarns by several counts.

The more the interlacings the more the shrinkage and therefore the greater the length of yarn required to produce a given width or length of cloth. A plain-woven cloth will require a greater length of yarn than a 2-up and 1-down twill and this in turn will require a greater length of yarn than a 2-up and 2-down twill. Using print-cloth yarns of the same counts, a 40×40 tobacco cloth will shrink less in warp and filling than will a 60×60 print cloth and this in turn will shrink less than an 80x80 longcloth.

When sley and pick are equal and the warp and filling of the same counts, the contraction will be nearly equal in width and in length; the greater tension on the warp yarn in some cases making the filling contraction slightly the greater.

In ordinary plain cloths, where the warp and filling yarns do not differ greatly, and the sley is slightly in excess of the pick, the filling contraction exceeds the warp contraction. In a 64×60 print cloth made of 30s and 40s yarns the warp contraction will normally be around 5¾% and the filling contraction around 6½%. Using the same yarns but making the cloth 60×64 the warp contraction would be around 6½% and the filling contraction around 5¾%.

Warp sateens will shrink more in width and less in length than will filling sateens of the same class.

Fine-yarn goods shrink less than coarse yarn

goods. The coarser and stiffer the yarn the greater the shrinkage.

Soft-spun filling is flattened by harder twisted warp and the warp contraction is therefore ordinarily less than would be the case if the filling was twisted as hard as the warp.

Ply yarns are normally harder twisted and therefore shrink more than would equivalent single counts.

The rules that the more the interlacings the more the shrinkage and the finer the yarns the less the shrinkage are subject to modifications for special conditions. In filling-corded fabrics such as repps and poplins, where the filling is considerably coarser than the warp and the sley greatly in excess of the pick, the filling lies almost straight and the warp does all the bending. This is due to the fact that the warp ends are too close together to afford room for the coarse filling to bend around them. Some velvets and other pile fabrics contain so many picks that beyond a certain point the warp contraction is decreased because the warp yarn is held and stretched beyond its elastic limit.

In fancy fabrics the shrinkage of different ends, due to difference in yarn counts or to difference in character of weave, is frequently such as to necessitate their being wound on separate beams. In some instances, however, this may be obviated by proper variation in reeding. For instance a warp satin stripe with a plain ground may be woven on one beam, because the warp ends in the stripe are drawn four or six to a dent, and being crowded together they do not have to lie as straight and flat as they would if drawn two to

a dent as are the warp ends for the plain ground.

The shrinkage or contraction is affected not only by the nature of the fabric but also by the loom on which it is woven. Cloth woven on a loom with a high take-up roller will not shrink as much in width as cloth woven on an ordinary loom. The greater the tension in weaving the more the shrinkage in width and the less the shrinkage in length. For instance, cloth woven on looms with stop motions will usually show one or two per cent more shrinkage in width and one or two per cent less shrinkage in length than would the same cloth on ordinary looms, this being due to the fact that the warp has to be kept more tightly stretched to prevent contact by the drop wires.

Any variation in the spacing of interlacings or in the diameter of the yarns means a variation in the contraction and hence in the length of yarn required to weave a certain length and width of cloth.

To find filling contraction, knowing cloth width and width warp in reed:

RULE 1.—*Subtract the width in cloth from the width in reed and divide by the width in reed.*

EXAMPLE: The warp for a 36-inch sheeting was spaced $39\frac{3}{8}$ inches in reed. What was the contraction from reed to cloth?

ANSWER: $\dfrac{39.375 - 36}{39.375} = 8.57\%$ filling contraction.

To find warp contraction, knowing cloth length and warp length:

RULE 2.—*Subtract the length of cloth from the length of warp and divide by the length of warp.*

EXAMPLE: A 40-yard cut of sheeting was made from 43¾ yards of warp. What was the contraction from warp to cloth?

ANSWER: $\dfrac{43.75 - 40}{43.75} = 8.57\%$ warp contraction.

To find length of filling or warp used, knowing cloth width or length and contraction percentages:

RULE 3.—*Divide the cloth width or length by 1 minus the percentage of contraction.*

EXAMPLE: A heavy sheeting is 36 inches wide and 40 yards long. If the filling contraction was 8.57% and the warp contraction also 8.57%, what was the width of warp in reed and the length of warp required?

ANSWER:

$$\frac{36 \text{ (inches)}}{1 - .0857} = \frac{36}{.9143} = 39.375 \text{ in. width in reed.}$$

$$\frac{40 \text{ (yards)}}{1 - .0857} = \frac{40}{.9143} = 43.75 \text{ yards warp required.}$$

CLOTH REGAIN

Expressed in inches, contraction and regain are the same. Expressed in percentages, as more

customary, contraction and regain are never the same, as the percentage of contraction is based on the original width or length, whereas the percentage of regain is based on the finished width or length. Errors are occasionally made in cloth calculations through confusing regain with contraction and an illustration may be useful in emphasizing the difference.

Suppose width of warp in reed to be 30 inches and width of cloth made therefrom to be 28½ inches. The warp has shrunk 1½ inches in width and the cloth would need to regain 1½ inches to attain its original width.

The percentage of contraction in width is the original width minus the finished width, divided by the original width. In this case,:

$$\frac{30 - 28\frac{1}{2}}{30} = \frac{1\frac{1}{2}}{30} = \frac{1}{20} = 5\% \text{ contraction.}$$

The percentage of regain to be added to the cloth width to give the original width of warp in reed is equal to the original width minus the finished width, divided by the finished width. In this case:

$$\frac{30 - 28\frac{1}{2}}{28\frac{1}{2}} = \frac{1\frac{1}{2}}{28\frac{1}{2}} = \frac{1}{19} = 5.26\% \text{ regain.}$$

The same relation between contraction and regain applies to the warp as well as to the filling. Suppose 63 yards of warp from the slasher are required to produce a 60 yard cut of cloth. Then the warp contraction is $\frac{63 - 60}{63} = 4.76\%$ and the warp regain is $\frac{63 - 60}{60} = 5\%$.

From the above the relationship between contraction and regain is seen to be as follows:

$$\text{Per cent contraction} = 1 - \frac{1}{1 + \%\ \text{regain}}$$

$$\text{Per cent regain} = \frac{1}{1 - \%\ \text{contraction}} - 1.$$

and $(1 - \%\ \text{contraction}) \times (1 + \%\ \text{regain}) = 1$

REED CALCULATIONS

Calculations for reed, for contraction in width, and for regain in width, are interdependent and a rule for one implies a rule for the others. This is sometimes overlooked and we have the anomaly afforded by a writer stating that it is impossible to formulate a rule for contraction in width and then going ahead and stating a rule for ascertaining the reed to give a certain sley.

There is one point here that should be noted. Contraction in width from reed to cloth is based on width of warp in reed, and regain from cloth to reed is based on cloth width. The ends per inch, however, are a reciprocal of the width, that is, 64 ends to the inch means that the threads are spaced one sixty-fourth of an inch apart. In reed calculations, therefore, the use of contraction and regain percentages must be the reverse of their use in width calculations. For instance, if the filling contraction for a 36-inch, 48 × 48, sheeting is 8.57% we would find width of warp in reed by dividing 36 by .9143 (i. e. by 1 minus 8.57%), obtaining 39.375 inches, but we would find the reed by multiplying 48 by .9143, obtaining 43.88 ends per inch in reed and this latter divided by 2 ends per dent would give 21.94 dents per inch.

Warps may be sleyed 1, 2, 3, 4, or even more ends to the dent; for ordinary plain cloth 2 ends to the dent is the rule. In reed calculations it is only necessary to give rules for finding the ends per inch in reed as the dents per inch are obtainable therefrom by dividing by a simple number.

To find dents per inch in reed, knowing ends per inch in reed and ends per dent:

RULE 4.—*Divide ends per inch in reed by ends per dent.*

EXAMPLE: A warp is to be drawn in with 60 ends to the inch in the reed. What reeds would be required if the warp were sleyed 1, 2, 3 or 4 ends per dent respectively?

ANSWER: If there are 60 ends to the inch a 60 reed is required for 1 end per dent; a 30 reed for 2 ends per dent; a 20 reed for 3 ends per dent; a 15 reed for 4 ends per dent.

To find number of dents occupied by an equally reeded warp, knowing total ends, selvage ends, and ends per dent:

RULE 5.—*From total ends subtract half the selvage ends and divide by number of ends per dent.*

EXAMPLE: A print cloth is woven with 2500 ends in the warp, including 32 selvage ends. How many dents required?

ANSWER: $$\frac{2500 - 16}{2} = 1242 \text{ dents total.}$$

To find width of warp in reed, knowing total ends in warp, selvage ends, ends per dent, and reed:

RULE 6.—*From total ends subtract half the selvage ends and divide by ends per dent and by dents per inch.*

EXAMPLE: A print cloth is woven with 2500 ends in the warp, of which 32 are selvage ends drawn in 4 ends to the dent. Using a 30 dent reed, what is width of warp in reed?

ANSWER: $\dfrac{2500 - 16}{2 \times 30} = 41.4$ inches in reed.

To find reed required to produce a given sley with a known or estimated contraction in width from reed to cloth:

RULE 7.—*Multiply ends per inch in cloth by 1 minus the percentage of filling contraction; divide result by ends per dent.*

EXAMPLE: A print cloth has 64 ends per inch in the cloth. How many dents per inch in reed if filling contraction be taken as $6\frac{1}{2}\%$?

ANSWER: $1 - .065 = .935$. $64 \times .935 = 59.84$. For plain cloth there are used 2 ends per dent so $59.84 \div 2 = 29.92$ dent reed.

NOTE—If the regain had been given instead of the contraction, say 6.95% filling regain, then the reed would have been found by division instead of by multiplication, thus $64 \div 1.0695 = 59.84$ and this divided by 2 ends per dent would have given the same 29.92 dent reed as above.

To find average number of ends per inch in an unequally reeded fabric, knowing the ends and dents per pattern and the reed:

RULE 8.—*Multiply number of ends in one pattern by number of reed; divide result by number of dents in pattern.*

EXAMPLE: What is the average number of ends per inch in reed if the warp is drawn in with 24 ends in 12 dents and 48 ends in 12 dents alternately, using a 30 dent reed?

ANSWER:

$$\frac{\text{72 ends in pattern} \times \text{30 dent reed}}{\text{24 dents in pattern}} = 90 \text{ average}$$

ends per inch in reed.

To find ends per inch in reed, knowing sley and yarn counts:

RULE 9.—*Square the distance between warp ends in cloth and add the square of the diameter of the average yarn count. The reciprocal of the square root of their sum is the number of ends per inch in reed.*

EXAMPLE: A print cloth is to be made with 64 ends of 30s warp and 60 picks of 40s filling. How many ends per inch in reed required?

ANSWER: The average yarn count is 33.8s and this has 33.8 × 840 or 28,392 yards per pound. The square root of 28,392 is 169 and the diameter of 33.8s yarn is therefore $\frac{1}{169}$ inch. The distance between warp ends is equal to the reciprocal of the sley, in this case it is 1/64 inch. Let r = distance between ends in reed, e = distance between ends in cloth, and d = diameter of average yarn count. Then

$$
\begin{aligned}
r^2 &= e^2 + d^2 \\
&= (1/64)^2 + (1/169)^2 && \text{(A)} \\
&= \frac{1}{4096} + \frac{1}{28{,}392} && \text{(B)} \\
&= \frac{32{,}488}{116{,}293{,}632} && \text{(C)} \\
&= \frac{1}{3580} && \text{(D)} \\
\text{and } r &= \frac{1}{59.84} && \text{(E)}
\end{aligned}
$$

Therefore 59.84 is number of ends per inch in reed.

With 2 ends to the dent we have $59.84 \div 2 = 29.92$ dents per inch in reed.

Since the diameter of yarn is equal to the reciprocal of the square root of the number of yards to the pound, and since the above rule calls for the squaring of the diameter, which gets back to the number of yards to the pound, the equation (A) may be eliminated and the above rule shortened to the following:

RULE 9-A.—*To the square of the reciprocal of the sley add the reciprocal of the number of yards to the pound of the average yarn count. The reciprocal of the square root of their sum is the number of ends per inch in reed.*

NOTE—From equation (B) it is seen that the spacing between ends in the cloth has a much more important influence on the reed and hence on the contraction between reed and cloth than

has the diameter of the yarns. In obtaining equation (C) we add 4096 and 28,392 to get the dividend 32,488 and multiply 4096 by 28,392 to get the divisor 116,293,632. Dividing 116,293,632 by 32,488 we simplify the equation (C) to the equation (D). The square root of the latter represents the distance between ends in the reed so its reciprocal 59.84 must be the number of ends per inch in the reed.

Having the number of ends per inch in the reed and in the cloth the contraction from reed to cloth is simply a matter of subtraction and division, thus in the above case $(64 - 59.84) \div 64 = 6.5\%$ filling contraction. The above rule for obtaining ends per inch in reed therefore implies also a rule for ascertaining the filling contraction.

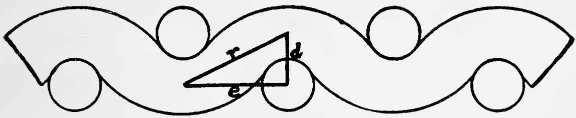


FIG. 1.

EXPLANATION OF RULE 9:

Rule 9 is almost obvious from Fig. 1 herewith which represents a cross section across the cloth and shows how a pick of filling is bent out of its course by having to pass over and under the warp threads. The relation of the reed to the sley is made plain from the triangle having one side marked *d*, one side marked *e*, and the sloping portion, which is known as the hypotenuse, marked *r*.

The side *d* represents the distance from the center of a filling thread to the center of a warp thread at the point where they cross, in other

words it is the average diameter of the two. As the diameter of the warp yarn is increased by the addition of sizing, *d* is taken as the diameter of the average yarn count. This is more correct than to use the diameter of the arithmetical average of the warp and filling before weaving but the margin of error in the latter case would usually be very slight.

The side *e* represents the distance between warp ends in the cloth and is therefore the reciprocal of the sley. The hypotenuse *r* represents the distance between warp ends in the reed, this is clear as it is the length of filling required to produce a width of cloth equal to the distance between warp ends. By mathematics the square of the hypotenuse of a right angled triangle is equal to the sum of the squares of the two sides, therefore $r^2 = e^2 + d^2$.

In rules that are often used for ascertaining the reed from the sley alone, disregarding the yarn count as the less important factor, there is used as a base a number that is 1 less than the sley and the reed figured from this with the use of an average regain or contraction of 5 per cent. The reduction of the sley by 1 is due to the necessity of obtaining a sliding rate of change in the regain or contraction that will approximate as near as may be to that obtained in actual practice where ordinarily the finer the reed the finer the yarn counts. We will state both rules and see how near they approach to the more accurate system outlined in Rule 9.

To find approximate ends per inch in reed, knowing sley:

RULE 10.—*Deduct* 1 *from the sley and multiply by* .95.

EXAMPLE: A cloth has 64 ends per inch. How many ends per inch in reed?

ANSWER: $64 - 1 = 63$. $63 \times .95 = 59.85$ ends per inch in reed. If 2 ends to the dent then the reed has $59.85 \div 2 = 29.92$ dents per inch.

To find approximate ends per inch in reed, knowing sley:

RULE 11.—*Deduct* 1 *from the sley and divide by* 1.05.

EXAMPLE: A cloth has 64 ends per inch. How many ends per inch in reed?

ANSWER: $64 - 1 = 63$. $63 \div 1.05 = 60$ ends per inch in reed. If 2 ends to the dent then the reed has $60 \div 2 = 30$ dents per inch.

NOTE.—$1 - 5\% = .95$. $1 + 5\% = 1.05$. It will be seen in Rule 10 there has been assumed a 5% contraction, and in Rule 11 a 5% regain, after subtracting 1 from the sley to compensate for the variation in contraction or regain due to variation in yarn counts.

CONTRAST OF RULES 9, 10 AND 11.

To contrast Rules 9, 10 and 11 we will first select three standard cloths and ascertain the results. Suppose we take a coarse cloth, say a 48 × 48, 14s.14s, sheeting; a medium cloth, say a 64 × 60, 30s.40s, print cloth; and a fine-yarn cloth, say an 88 × 80, 60s.100s, India linon. For the cloths stated the results according to the three rules would be as follows:

	Sheeting.	Print Cloth.	India Linon.
		Reed	
By Rule 9	21.95	29.92	41.50
By Rule 10	22.32	29.92	41.32
By Rule 11	22.38	30.00	41.43
		Contraction	
By Rule 9	8.54%	6.45%	5.70%
By Rule 10	7.00%	6.45%	6.08%
By Rule 11	6.75%	6.67%	5.95%

It is evident that the approximate Rules 10 and 11 are based on print cloth constructions and print cloth yarns. If Rule 9 is accepted as accurate for plain cloths then both of the approximate rules show too fine a reed, giving too little contraction, on coarse goods, and too coarse a reed, giving too much contraction, on fine goods. For coarse goods Rule 10 is more nearly correct than Rule 11, whereas on fine goods Rule 11 approximates better the actual conditions. The farther away from print cloth yarns used in print cloth constructions is the problem given the greater is the error in using the approximate rules 10 and 11.

The error in considering only the yarn spacing and disregarding the other factor of yarn diameters can be brought out by considering different yarn counts used in the same reed. For instance, let us compare a wide sheeting, say a 63-inch, 64 × 68, 21s.24s, 2 yds. per lb., and a print cloth, say the 38½-inch, 64 × 60, 30s.40s, 5.35 yds. per lb. In the first case the average yarn count is 22.4s and in the latter case 33.8s. Using Rule 9 we find that the sheeting was woven with a 29 reed and the print cloth with a 29.92 reed. According to approximate rule 10 both would be

woven with a 29.92 reed, and according to approximate rule 11 both would be woven with 30 reed. Rules 10 and 11 would therefore show filling contraction for both sheeting and print cloth to be the same, 6.45% according to the first rule and 6.67% according to the second. That this is not correct is obvious and Rule 9 brings out the true condition, that the filling contraction on the sheeting would be 9.375% as compared with 6.45% on the print cloth.

To find sley that would be woven with a given reed and yarn counts:

RULE 12.—*From the square of the distance between ends in the reed, subtract the reciprocal of the yards per pound of the average yarn count. The reciprocal of the square root of their difference is the sley.*

NOTE—This rule is derived from RULE 9-A.

EXAMPLE: A wide sheeting is to be woven with 21s warp and 24s filling, using a 29 dent reed. How many ends per inch in the cloth produced?

ANSWER: The ends per inch in reed are $29 \times 2 = 58$. The distance between ends in the reed is therefore 1/58 and this squared is 1/3364. The average yarn count is 22.4s and this contains $22.4 \times 840 = 18{,}816$ yards to the pound. Then from Fig. 1 and explanation under Rule 9, we

know that $r^2 = e^2 + d^2$, therefore

$$e^2 = r^2 - d^2$$

$$= \frac{1}{3364} - \frac{1}{18{,}816}$$

$$= \frac{15{,}452}{63{,}297{,}024}$$

$$= \frac{1}{4096}$$

$$\text{and } e = \frac{1}{64}$$

Therefore sley = 64 ends per inch in cloth.

To find approximate sley that would be woven with a given reed:

RULE 13.—*Divide ends in reed by* .95 *and add* 1.

RULE 13-A.—*Multiply ends in reed by* 1.05 *and add* 1.

EXAMPLE: A wide sheeting is to be woven with 21s warp and 24s filling, using a 29 dent reed. How many ends per inch in cloth produced?

ANSWER: $(29 \times 2) \div .95, + 1 = 61 + 1 = 62$ ends per inch in cloth.

ANSWER: $(29 \times 2) \div 1.05, + 1 = 60.9 + 1 = 61.9$ ends per inch in cloth.

NOTE—These approximate rules are based on Rules 10 and 11. In this case of a standard cloth which uses coarse yarns in a medium reed the margin of error is even larger than in the contrast made after Rule 11 where coarse yarns were

used in a coarse reed, medium yarns in a medium reed, and fine yarns in a fine reed. Rules 10, 11, 13 and 13-A are safe only for print cloth yarns in print cloth constructions and to find reed from sley or sley from reed it is safest to use Rules 9 and 12.

WARP LENGTH COMPARED WITH CLOTH LENGTH

To find length of warp required to produce a given length of cloth, knowing picks per inch and yarn counts.

RULE 14.—*Square the reciprocal of the pick and add the reciprocal of the number of yards to the pound of the average yarn count. Obtain the reciprocal of the square root of their sum. Subtract this from the pick and divide by the pick to get percentage of warp contraction. The length of cloth required divided by 1 minus the per cent. warp contraction gives length of warp required.*

NOTE—This Rule is derived from Rule 9-A.

EXAMPLE: A print cloth is made with 64 ends of 30s warp and 60 picks of 40s filling. How many yards of warp required for a 60 yard cut of cloth?

ANSWER: Pick = 60. $(1/60)^2 = 1/3600$. Average yarn count is 33.8s and this has 33.8×840 or 28,392 yards to the pound. Then

$$r^2 = \frac{1}{3600} + \frac{1}{28{,}392}$$

$$= \frac{31{,}922}{102{,}211{,}200}$$

$$= \frac{1}{3195}$$

$$\text{and } r = \frac{1}{56.52}$$

The warp contraction = (60 — 56.52) ÷ 60 = 5.6%.

The length warp required = 60 yards ÷ (1 — 5.6%) = 60 ÷ .944 = 63.55, say 63½ yds.

NOTE—Attempts have been made by some to formulate empirical rules for quickly ascertaining the approximate percentage of warp contraction. A rule that is often given is: "Multiply the pick by 3.5 and divide by the counts of the filling." This is a very unsafe rule; nine times out of ten the results are entirely wrong. For instance it would show the warp contraction on a 48 × 48, 14s.14s, sheeting as 12%, whereas Rule 14 would prove it to be the same as the filling contraction or 8.54%; it would show the warp contraction on a 64 × 60, 30s.40s, print cloth as 7%, whereas Rule 14 shows it to be 5.60%; it would show the warp contraction on an 88 × 80, 60s.100s, India linon as 2.80%, whereas Rule 14 shows it to be 4.78%. This approximate rule is an attempt to take into consideration both the spacing and the yarn counts but goes at it in a more or less hit-or-miss method.

Warp contraction, like filling contraction, is based on the spacing and the yarn diameters so if an approximate rule is desired the best results would be obtained from an adaptation of Rule 10, thus

To find approximate warp contraction, knowing pick:

RULE 15.—*Deduct* 1 *from the pick and multiply by* .95. *Subtract result from the pick and divide by the pick.*

EXAMPLE: A cloth has 60 picks per inch. What is warp contraction?

ANSWER: $60 - 1 = 59$. $59 \times .95 = 56.05$.

$$\frac{60 - 56.05}{60} = 6.58\%.$$

Knowing cloth length and warp contraction the length warp required in this case is 60 yards $\div$ $(1 - 6.58\%) = 60 \div .9342 = 64.22$ yards.

NOTE—This rule would show, similarly, 7% warp contraction for a 48×48, 14s.14s, sheeting and 5.56% warp contraction for a 88×80, 60s.100s, India linon. As in the case of Rule 10 it gives too little contraction on coarse goods and too much contraction on fine goods but is a closer approximation than the rule for dividing pick by filling counts and multiplying by 3½. It is much safer to use Rule 14, which is much simpler to operate than to state, even though a few more figures are involved, than to use rough approximations which may or may not be within speaking distance of the correct answer.

To find length of warp required for a given length of special cloths such as lenos, lappets, or towels:

RULE 16.—*Measure off a convenient length in the cloth, say 36 inches, and cut; take out ends of special yarns included, straighten without stretching, and re-measure. The length of the yarn out of the cloth minus the length of the yarn in the cloth, divided by the length of the yarn out of the cloth, is the warp contraction of each.*

EXAMPLE: The ground threads from a yard of lappet-woven cloth, after straightening without stretching, measure 38 inches; similarly the lappet ends from a yard of cloth measure 60 inches. What was the warp contraction of each kind of yarns?

ANSWER: Ground ends: $(38 - 36) \div 38 = 5.26\%$ warp contraction.

Lappet ends: $(60 - 36) \div 60 = 40\%$ warp contraction.

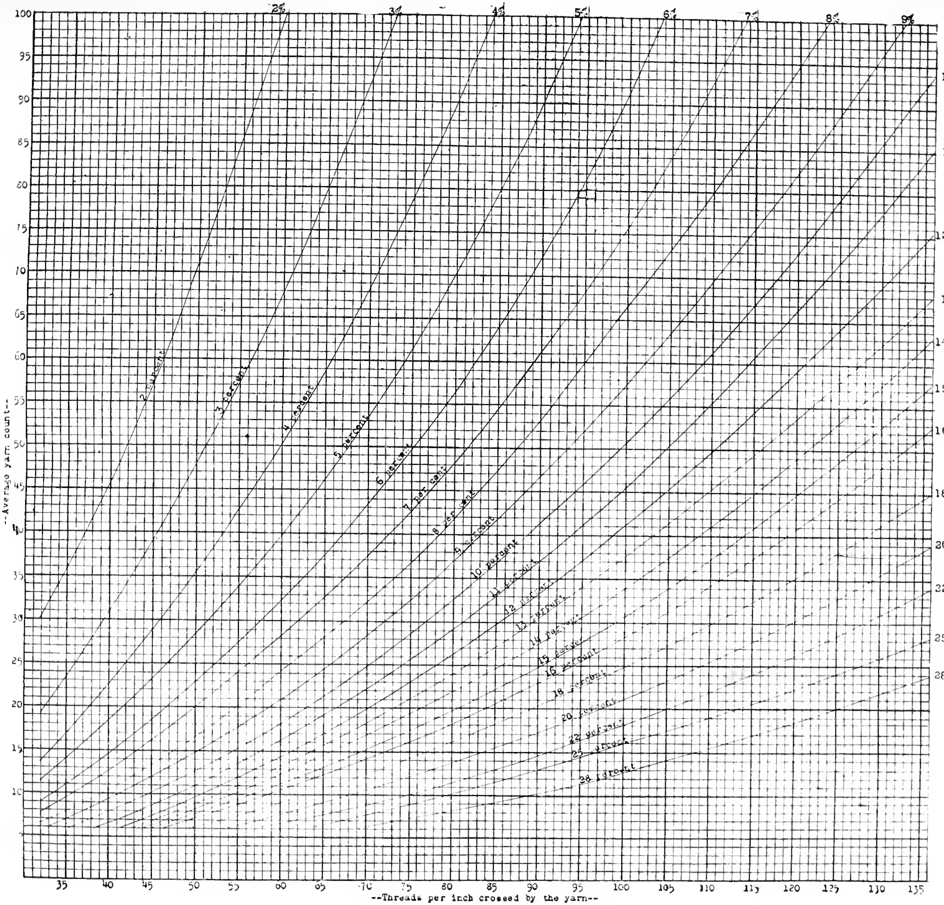
NOTE—This operation has to be performed very carefully so as to get the correct original length of the yarns by taking out all of the waviness without unduly stretching. It is best to take at least 36 inches for with a short length such as 5 or 10 inches the margin of possible error would be much increased.

CONTRACTION IN WEAVING PLAIN CLOTHS

Calculations for the reed to produce a given sley and for the slasher length required to produce a given length of cut are both based on the ascertainment of the percentage of contraction or take-up in weaving. It has been shown that for any individual case Rule 9, with the derived Rule 14, will give accurate results. For the convenience of those who have to ascertain either the reed or the warp length the following table, based on Rule 9, has been worked out to show the contraction in warp and in filling in the weaving of plain cloths. The table is arranged to include all plain cotton cloths using from 6s up to 100s yarns and constructions of from 32 to 136 ends per inch. It has been charted so that any intermediate set of conditions can be readily ascertained without the necessity of working out the formula given.

The contraction in weaving depends primarily on the threads per inch crossed by the yarn, warp or filling, and secondarily on the average yarn count. The size of warp and of filling yarns together affect both warp and filling contraction, so that the average yarn count is the correct basis to use. If the average yarn count is not known accurately then it is permissible to use the arithmetical average of the warp and filling counts as the margin or error in such case will usually be small.

In using the table or chart the fact should be borne in mind that the contraction of warp yarn depends most largely on the number of picks



PERCENTAGE OF CONTRACTION IN WEAVING PLAIN CLOTH.

Contraction In Weaving Plain Cloths

Average yarn count	Threads per inch crossed by the yarn																										
	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	124	128	132	136
6	8.8	10.8	12.9	15.0	17.1	19.3	21.3	23.4	25.6	27.8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7	7.7	9.5	11.4	13.3	15.2	17.1	19.0	21.0	23.0	25.0	27.0	29.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	6.8	8.4	10.1	11.9	13.7	15.5	17.3	19.1	20.9	22.7	24.6	26.5	28.4	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9	6.1	7.6	9.2	10.8	12.5	14.2	15.9	17.6	19.3	21.0	22.7	24.5	26.3	28.1	....	....	....	....	....	....	....	....	....	....	....	....	....
10	5.6	7.0	8.4	9.9	11.4	13.0	14.6	16.2	17.9	19.6	21.3	23.0	24.6	26.3	28.0	....	....	....	....	....	....	....	....	....	....	....	....
12	4.7	5.8	7.1	8.4	9.8	11.2	12.7	14.2	15.7	17.2	18.7	20.2	21.7	23.2	24.7	26.2	27.9	....	....	....	....	....	....	....	....	....	....
14	4.1	5.0	6.1	7.3	8.6	9.9	11.2	12.5	13.9	15.3	16.7	18.1	19.5	20.9	22.3	23.7	25.1	26.5	27.9	....	....	....	....	....	....	....	....
16	3.6	4.5	5.5	6.5	7.6	8.7	9.9	11.1	12.4	13.7	15.0	16.3	17.6	18.9	20.2	21.5	22.8	24.2	25.6	27.0	28.4	....	....	....	....	....	....
18	3.2	4.1	5.0	5.9	6.8	7.9	9.0	10.1	11.3	12.5	13.7	14.9	16.1	17.3	18.5	19.8	21.1	22.4	23.6	24.8	26.0	27.2	28.4	....	....	....	....
20	2.9	3.7	4.5	5.3	6.2	7.2	8.2	9.2	10.3	11.4	12.5	13.6	14.8	16.0	17.2	18.4	19.6	20.8	22.0	23.2	24.3	25.4	26.5	27.4	28.8	....	....
22	2.7	3.4	4.1	4.9	5.7	6.6	7.5	8.5	9.5	10.5	11.6	12.7	13.8	14.9	16.0	17.1	18.2	19.3	20.4	21.5	22.6	23.7	24.8	25.9	27.0	28.2	....
24	2.5	3.1	3.8	4.5	5.3	6.1	6.9	7.8	8.8	9.8	10.8	11.8	12.8	13.8	14.8	15.9	17.0	18.1	19.2	20.3	21.4	22.5	23.6	24.7	25.8	26.8	27.8
26	2.3	2.8	3.4	4.1	4.9	5.7	6.5	7.3	8.2	9.1	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.1	19.2	20.3	21.4	22.4	23.4	24.4	25.4	26.4
28	2.1	2.6	3.2	3.8	4.5	5.2	6.0	6.8	7.7	8.6	9.4	10.3	11.3	12.2	13.2	14.2	15.2	16.2	17.2	18.2	19.2	20.2	21.2	22.2	23.2	24.2	25.2
30	2.0	2.4	2.9	3.6	4.2	4.9	5.6	6.4	7.2	8.0	8.9	9.8	10.7	11.6	12.5	13.4	14.4	15.4	16.4	17.3	18.2	19.2	20.2	21.2	22.2	23.2	24.1
32	1.9	2.3	2.8	3.4	4.0	4.6	5.3	6.0	6.8	7.6	8.4	9.2	10.1	11.0	11.9	12.8	13.7	14.6	15.5	16.4	17.3	18.2	19.1	20.0	21.0	22.0	23.0
34	1.8	2.2	2.7	3.2	3.8	4.4	5.1	5.8	6.5	7.2	8.0	8.8	9.6	10.4	11.2	12.1	13.0	13.9	14.8	15.7	16.6	17.5	18.4	19.3	20.2	21.1	22.0
36	1.7	2.1	2.6	3.1	3.6	4.2	4.8	5.5	6.2	6.9	7.6	8.4	9.2	10.0	10.8	11.6	12.4	13.3	14.1	14.9	15.8	16.7	17.6	18.5	19.4	20.3	21.2
38	1.6	2.0	2.4	2.9	3.4	4.0	4.6	5.2	5.9	6.6	7.3	8.0	8.8	9.6	10.4	11.2	12.0	12.7	13.5	14.3	15.1	15.9	16.8	17.7	18.6	19.5	20.4
40	1.5	1.8	2.2	2.7	3.2	3.8	4.4	5.0	5.6	6.2	6.9	7.6	8.3	9.1	9.8	10.6	11.4	12.2	13.0	13.8	14.6	15.4	16.2	17.0	17.9	18.8	19.6
45	1.4	1.7	2.0	2.4	2.9	3.4	3.9	4.4	5.0	5.6	6.2	6.8	7.5	8.2	8.9	9.6	10.3	11.0	11.8	12.6	13.3	14.0	14.8	15.6	16.4	17.2	18.0
50	1.2	1.5	1.8	2.2	2.6	3.0	3.5	4.0	4.5	5.0	5.6	6.2	6.8	7.4	8.0	8.7	9.4	10.1	10.8	11.5	12.2	12.9	13.6	14.3	15.0	15.8	16.6
60	1.0	1.3	1.6	1.9	2.2	2.6	3.0	3.4	3.8	4.3	4.8	5.3	5.8	6.3	6.9	7.5	8.1	8.7	9.3	9.9	10.5	11.1	11.7	12.2	13.1	13.8	14.5
70	.9	1.1	1.3	1.6	1.9	2.2	2.5	2.9	3.3	3.7	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6	9.1	9.7	10.3	10.9	11.5	12.1	12.7
80	.8	1.0	1.2	1.4	1.7	2.0	2.3	2.6	2.9	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.2	6.7	7.2	7.7	8.2	8.7	9.2	9.7	10.3	10.9	11.5
90	.7	.8	1.0	1.2	1.5	1.7	2.0	2.3	2.6	2.9	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.9	7.4	7.9	8.4	8.9	9.4	9.9	10.4
100	.6	.7	.9	1.1	1.3	1.5	1.7	2.0	2.3	2.6	2.9	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.9	9.5

around which the warp has to bend; also that the contraction of filling yarn depends most largely on the number of warp ends around which the filling has to bend.

As an illustration of the method of using this table let us take a 39-in., 68x72, 30s.40s, 4.75-yard print cloth. Suppose the average yarn count is 34s. The 34s is found on the left hand side of the table and by following the horizontal line until we reach the vertical column headed 72 threads we find that the warp contraction or take-up in weaving will be 8 per cent. The 72 threads in this case represent the picks with which the warp interlaces. The filling interlaces with 68 warp ends and by finding the intersection of the 34s average yarn count and the vertical column marked 68, which in this case represents warp ends, we find that the filling contraction or take-up in weaving is 7.2 per cent.

Knowing the contractions the results desired are easily obtained. For a 60 yard cut we would need 60 divided by 1 minus 8%, which is 60 divided by .92, or 65¼ yards from the slasher. The reed required would be 68 (sley) multiplied by 1 minus 7.2%, which is 68 × .928, or 63.1 ends per inch in the reed; this divided by 2 ends per dent would give 31.5 dents per inch reed required.

AVERAGE YARN COUNT

The ascertainment of the average yarn count in a cloth is a matter of prime importance as this factor is necessary as a basis in making or proving various other calculations dealing with cloth. To obtain the average yarn count accurately it is necessary to take into consideration the contraction or take-up of warp and of filling and also the percentage of sizing added to the warp.

The average yarn count is rarely the same as the arithmetical average of the warp and filling counts; it is usually coarser by reason of there being a larger proportion of the coarser than of the finer counts involved. For instance if a cloth is made with 60s warp and 100s filling the arithmetical average would be 60 plus 100, divided by 2, which would give 80s. Taking into consideration contraction and sizing and the larger percentage of warp than of filling the average yarn count is more likely to be around 74s.

The basic formula in cotton cloth calculations is

FORMULA I: $AC = BYT$

where A = Average yarn count.
C = Cloth constant.
B = Breadth or width of cloth in inches.
Y = Yards per pound.
T = Total threads per square inch.

The above is an exact equation as each side of the equation represents the number of yards that weigh one pound. The English cotton yarn numbering system is based on the count indicating

the number of 840-yard hanks that weigh one pound, so the yarn count times 840 equals yards of yarn per pound. If there were no contraction or sizing then C would equal 840. Under actual conditions, C, a length of yarn, as measured in the cloth, that weighs the same as a hank of the yarn as spun, must always be less than 840 by reason of the contraction and sizing. Under all circumstances the average yarn count A, multiplied by the cloth constant C, will represent the number of yards of yarn that weigh one pound. T, which is the sum of the number of threads of warp and filling in one square inch, necessarily represents the inches of yarn as measured in one square inch of the cloth; this multiplied by B, the cloth width, equals the inches of yarn in one inch of cloth of that width or the number of yards of yarn in one linear yard of cloth; this in turn multiplied by Y, the linear yards of cloth per pound, equals the yards of yarn in one pound of the cloth. Therefore AC represents yards of yarn to the pound, and BYT represents yards of yarn to the pound, and consequently AC = BYT.

To find average yarn count in a cloth when width, weight, sley and pick, and cloth constant are known:

RULE 17: *Multiply width of cloth in inches by yards per pound and by total threads per square inch; divide product by suitable cloth constant that allows for contraction and sizing.*

The above may be expressed, by transposition

of the basic Formula 1, as

FORMULA 2: $A = \dfrac{BYT}{C}$

EXAMPLE 1: A heavy sheeting is made 36 inches, 48x48, 3 yds. per lb. If the cloth constant is 735, what is the average yarn count?

ANSWER: $A = \dfrac{BYT}{C} = \dfrac{36 \times 3 \times 96}{735} = 14s$ average yarn count.

EXAMPLE 2: A print cloth is made 38½ inches, 64x60, 5.35 yds. per lb. If the cloth constant is 756, what is the average yarn count?

ANSWER: $A = \dfrac{BYT}{C} = \dfrac{38.5 \times 5.35 \times 124}{756} =$ 33.8s average yarn count.

EXAMPLE 3: An India linon is made 30 inches, 88x80, 11.35 yds. per lb. If the cloth constant is 775, what is the average yarn count?

ANSWER: $A = \dfrac{BYT}{C} = \dfrac{30 \times 11.35 \times 168}{775} =$ 73.8s average yarn count.

To find average yarn count in a cloth when warp and filling counts and percentages of warp and filling are known:

RULE 18: *Multiply the warp count by the percentage of sized warp and the filling count by the percentage of filling. Add their products.*

EXAMPLE: A print cloth is made of 30s warp and 40s filling. The sized warp constitutes 60% and the filling 40% of the weight of the cloth. What is the average yarn count?

ANSWER: $30 \times .60 = 18$
$40 \times .40 = 16$

$34 =$ average yarn count.

To find average yarn count in a cloth when width, weight, sley and pick, and percentages of contraction and sizing are known:

RULE 19. *Divide total ends in warp by* 1 *minus percentages for warp contraction and sizing. Multiply cloth width by picks per inch and divide by* 1 *minus percentage for filling contraction. Add foregoing lengths of warp and filling; multiply by yards per pound and divide by* 840.

EXAMPLE: A grey shirting is woven 40 inches, 80x92, 3½ yds. per lb. Warp contraction 12%, sizing on warp 6%, filling contraction 9½%. What is average yarn count?

ANSWER: Total ends in warp $= 40 \times 80 = 3200$. $3200 + 40$ selvage ends $= 3240$.

$3240 \div (1 - 18\%$ contraction and sizing$) = 3240 \div .82 = 3951$ equivalent yards of warp.

(40 inches $\times$ 92 picks) $\div$ ($1 - 9½\%$ contraction) $= 3680 \div .905 = 4066$ yards of filling.

$3951 + 4066 = 8017$ yards yarn in one linear yard of cloth.

(8017 yards yarn $\times$ 3.50 yds. per lb.) $\div 840 =$ 33.4s average yarn count.

NOTE—The yards of warp shown are the equiv-

alent yards considering sizing as yarn. The actual length of warp yarn would be 3240 divided by 1 minus 12% contraction or 3682 yards. In calculations involving length only 3682 would be used but where the weight in yards per pound enters in it is necessary to add to the actual warp length a length equivalent to the sizing and thus 3951 as used above is correct.

To find average yarn count in a cloth when sley, pick, counts of warp and filling, and contraction and sizing percentages are known:

RULE 20: *Divide ends per inch by 1 minus percentages for warp contraction and sizing. Divide picks per inch by 1 minus percentage for filling contraction. Divide each of above quotients by its own yarn count; add the results and divide into the equivalent inches of yarn in a square inch.*

EXAMPLE: A grey shirting is woven with 80 ends per inch of 30s warp, having contraction of 12% and sized 6%; and with 92 picks of 38s filling, having contraction of 9½%. What is average yarn count?

ANSWER: 80 ÷ (1 — 18%) = 80 ÷ .82 = 97.6 inches of warp required to produce an inch of cloth, considering sizing as yarn.

92 ÷ (1 — 9½%) = 92 ÷ .905 = 101.7 inches of filling required to produce an inch of cloth.

Then:

97.6	÷	30s	=	3.25	(relative weight of warp)
101.7	÷	38s	=	2.68	(relative weight of warp)
199.3	÷			5.93	= 33.6s average yarn count

NOTE—The above is based on the fact that the

length divided by the count times 840 is equivalent to the weight, and that the length divided by the weight is equivalent to the counts times 840. The sley and pick represent inches of yarn in a square inch, as measured in the cloth, and allowing for contraction and size, represent inches of yarn used to produce a square inch, considering sizing as yarn. As they represent the inches of yarn in a square inch or the yards of yarn in a square yard the lengths 97.6 and 101.7 may be considered as hanks and 840, the yards per hank, are therefore omitted from the calculations. The above gives exact results but where contraction and sizing percentages are unknown fairly approximate results can be obtained from the following rule which is largely used.

To find average yarn count in a cloth when sley, pick, and counts of warp and filling, are known:

RULE 21: *Divide sley by warp count, and pick by filling count. Add the results and divide into sum of sley and pick.*

EXAMPLE: A grey shirting is woven with 80 ends of 30s warp and 92 picks of 38s filling to the square inch. What is the average yarn count?

ANSWER:

$$
\begin{array}{rcl}
80 \div 30s & = & 2.67 \\
92 \div 38s & = & 2.42 \\
\hline
172 \quad \div & & 5.09 = 33.8s \text{ average yarn count}
\end{array}
$$

NOTE—The average yarn count as obtained by this abbreviated rule is usually not materially

different from the results obtained by the more accurate Rule 20, but where the contractions in warp and filling are very different, for instance in such goods as venetians or crepes, there is a larger variation.

To find average yarn count in a cloth containing more than one count of warp or filling, when ends and picks of each count of yarn are known:

RULE 22: *Divide average sley by average warp count. Divide number of single threads of filling in an inch by average filling count. Add the results and divide into the sum of the average sley and pick.*

NOTE—This rule is based on Rule 21. In finding the average sley, average pick, and average yarn count, it is necessary to first reduce all ply yarns to equivalent single yarns.

EXAMPLE: A mercerized corded check is woven 36 inches wide, using 2736 ends of 70/1 plain and 432 ends of 10/2 mercerized; and having 76 picks of 90/1 plain and 8 picks of 24/2 mercerized, to the inch. What is the average yarn count?

ANSWER:

432 ends of 10/2 = 864 ends of 10s.
864 + 2736 = 3600 single threads in warp.
3600 ÷ 36 inches = 100 average sley.

864 ÷ 10s = 86.40
2736 ÷ 70s = 39.09

3600 ÷ 125.49 = 28.69 aver. warp count.

8 picks of 24/2 = 16 single threads of 24s.
16 + 76 = 92 single thread of filling in an inch.

16 ÷ 24s = .667
76 ÷ 90s = .844

92 ÷ 1.511 = 60.89 average filling count.

Then:

100 average sley divided by 28.69 average warp	= 3.485
92 single threads of filling divided by 60.89 average filling	= 1.511
192 total single threads yarn in square inch divided by	4.996

= 38.43s average yarn count.

To find average yarn count in a cloth containing more than one count of warp or filling, when ends and picks of each count of yarn are known:

Rule 23: *Divide the average number per inch of single threads of each kind of yarn by its yarn count; add the results and divide into total threads per square inch.*

Note—This is an abbreviation of Rule 22.

Example: (Same as in Rule 22.)

Answer: This mercerized corded check averages 24 single threads of 10s warp and 76 single threads of 70s warp to the inch; it has 16 single threads of 24s filling and 76 single threads of 90s filling to the inch.

Then:

$$
\begin{array}{rcrcl}
24 & \div & 10s & = & 2.400 \\
76 & \div & 70s & = & 1.086 \\
16 & \div & 24s & = & .667 \\
76 & \div & 90s & = & .844 \\
\hline
192 & \div & & & 4.997 = 38.43s \text{ aver. yarn count.}
\end{array}
$$

THE CLOTH CONSTANT

In cloth calculations there is an appreciable saving of time and effort in using a constant that automatically allows for contraction in width from reed to cloth, for contraction in length from slasher to cloth, and for the addition of sizing to the warp. The "cloth constant" is frequently stated as 756 or 764, and apparently no book on textile calculations shows how these constants are obtained or under what conditions they are correct. We propose to show the theory underlying this matter so that, knowing the particulars in regard to the cloth under consideration and the conditions under which it is woven, any one can figure out the correct cloth constant.

At the start, it may be noted that the term "constant" does not mean constant for all conditions but constant only for one set of conditions. Cloth constants actually used vary from less than 700 up to over 800, although for ordinary plain cloths they are usually between 735 and 775.

The "cloth constant" is based on the hank of 840 yards and represents a length of yarn, as measured in the cloth, that is equivalent in weight to a hank of the average of warp and filling counts before sizing or weaving.

In figuring the cloth constant it is usual to consider the take-up or contraction in length of yarn during weaving and the addition of sizing as having the same effect, as either results in the yarn in the cloth measuring less to the pound than the same yarn as spun. For instance, using 30s warp, we know that it measures 840×30, or 25,200 yards to the pound. If it takes up 10% in weaving it occupies a length in the cloth of $25{,}200 \times .90$ or 22,600 yards; 22,600 divided by 840 equals 27s so that after take-up 30s may be

considered as 27s. 30 — 10% = 27s. If the 30s was sized 10% it would be very slightly finer than 27s. If the 30s was sized 5% and the take-up in weaving was 5%, the equivalent count in the cloth would also approximate very close to 27s. In any one of these three cases we could, for cloth calculation purposes, disregard contraction and sizing, and figure on 27s instead of 30s or, to put it another way, figure that each hank had contracted 10% and therefore measured 756 yards instead of 840 yards.

To obtain a constant that will allow for contraction and sizing, so that in cloth calculations these may be disregarded and the yarn considered as lying in the cloth in a straight line and unsized, it is necessary to know the percentages of warp and of filling in the cloth, in addition to the contraction in width, the contraction in length, and the percentage of sizing added to the warp.

The constant 764 is primarily based on the assumption that there is 6% contraction from reed to cloth, 6% contraction from slasher length to cloth length, and 6% sizing added to the warp, also that the weight of filling and of sized warp in the cloth are the same. If the filling contracts 6% then a hank of 840 yards will measure in the cloth a distance equal to 840 × .94 or 789.6 yards. If the warp contracts 6% a hank also measures 840 × .94 or 789.6 yards in the cloth, but it is also sized 6% and this, for cloth calculation purposes, may be considered as having the same effect as contraction. 6% + 6% = 12%. 1 — 12% = .88. Then 840 × .88 = 739.6. On the assumption that warp and filling each account for 50% of the weight of the cloth, we then obtain the cloth constant as follows:

$$
\begin{aligned}
\text{Warp} &= 840 \times .88 \times .50 = 369.6 \\
\text{Filling} &= 840 \times .94 \times .50 = 394.8 \\
\text{Cloth constant} &= 764.4, \text{ say } 764.
\end{aligned}
$$

An idea of the range of cloth constants to be expected can be obtained by assuming the weight of warp and of filling in the cloth to be the same and figuring out the results with some normal variations in contraction and sizing. For instance the following may be taken as representative:

Pct. of sized warp.	Pct. of filling.	Warp contraction.	Sizing on warp.	Filling contraction.	Cloth constant.
50%	50%	4%	4%	4%	790
50%	50%	5%	5%	5%	777
50%	50%	6%	6%	6%	764
50%	50%	7%	6%	7%	756
50%	50%	7%	7%	7%	752
50%	50%	8%	7%	8%	743
50%	50%	9%	7%	9%	735
50%	50%	10%	7%	10%	727

Some mills use the constant 735 for heavy sheetings, 745 for sheetings, 756 for print cloths, and 775 for India linons, and obtain fairly approximate results. The exact constant will vary according to any variation in the percentage of warp or of filling, of contraction in width or in length ,or of the percentage of sizing added to the warp.

The percentages of warp and of filling are rarely exactly the same so we shall first put the result of the above analysis as a rule and then give a few examples illustrative of the cloth constants that would be obtained for typical standard cloths.

To find the cloth constant, knowing percentages of warp and of filling, contraction and sizing of warp, and contraction of filling:

RULE 24: *Subtract the percentages of warp contraction and sizing from* 1, *and multiply by* 840 *and by the percentage of sized warp in the cloth. Subtract the percentage of filling contraction from* 1, *and multiply by* 840 *and by the percentage of filling in the cloth. The sum of the two products is the cloth constant to be used to allow for contraction and sizing.*

EXAMPLE 1: No 3 sail duck is 22-in. wide, has 29 ends of 7/4 ply warp and 22 picks of 7/5 ply filling to the square inch. It weighs 16 ounces per yard or 1 yard per pound. Warp is 57% and filling 43% of the cloth weight. No sizing is used on such coarse ply warps so that factor is eliminated. If the warp contraction is 15% and filling contraction 20%, what is the cloth constant?

ANSWER:

Warp: $840 \times .85 \times .57 = 406.98$

Filling: $840 \times .80 \times .43 = 288.96$

Cloth constant = 695.94, say 696.

EXAMPLE 2: A heavy sheeting is woven 36 inches, 48 × 48, 14s.14s, 3 yds. per lb. Warp 53%, filling 47%. Warp contraction 8½%, sizing on warp 7%, filling contraction 8½%. What is the cloth constant?

ANSWER:

Warp: $840 \times .845 \times .53 = 376.19$

Filling: $840 \times .915 \times .47 = 361.24$

Cloth constant = 737.43 say 737.

EXAMPLE 3: A sheeting is woven 36 inches, 56×60, 21s.24s, 4 yds. per lb. Warp 54%, filling 46%. Warp contraction 8%, sizing on warp 7%, filling contraction 7%. What is the cloth constant?

ANSWER:

Warp: $840 \times .85 \times .54 = 385.56$
Filling: $840 \times .93 \times .46 = 359.35$

Cloth constant $= 744.91$, say 745.

EXAMPLE 4: A print cloth is woven 38½ inches, 64×60, 30s.40s, 5.35 yds. per lb. Warp 60%, filling 40%. Warp contraction 6%, sizing on warp 6%, filling contraction 6½%. What is the cloth constant?

ANSWER:

Warp: $840 \times .88 \times .60 = 443.52$
Filling: $840 \times .935 \times .40 = 314.16$

Cloth constant $= 757.68$, say 758.

EXAMPLE 5: A grey shirting is woven 40 inches, 80×72, 50s.60s, 6.80 yds. per lb. Warp 57%, filling 43%. Warp contraction 5.2%, sizing on warp 5%, filling contraction 6.3%. What is the cloth constant?

ANSWER:

Warp: $840 \times .898 \times .57 = 429.96$
Filling: $840 \times .937 \times .43 = 338.44$

Cloth constant $= 768.40$, say 768.

EXAMPLE 6: An India linon is woven 30 inches, 88×80, 60s.100s, 11.35 yds. per lb. Warp 65%, filling 35%. Warp contraction 4.8%, sizing on

warp 4%, filling contraction 5.7%. What is the cloth constant?

ANSWER:
Warp: $840 \times .912 \times .65 = 497.95$
Filling: $840 \times .943 \times .35 = 277.24$

Cloth constant $= 775.19$, say 775.

To find cloth constant, knowing width, weight, construction, and average yarn count:

RULE 25: *Multiply width in inches by yards per pound and by total threads per square inch; divide product by average yarn count.*

The above may be expressed, by transposition of the basic formula 1, as

FORMULA 3: $$C = \frac{BYT}{A}$$

EXAMPLE: A print cloth is woven 39 inches 68×72, 30s.40s, 4.75 yds. per lb. Average yarn count is 34.1s. What is the cloth constant?

ANSWER: $$C = \frac{BYT}{A} = \frac{39 \times 4.75 \times 140}{34.1} =$$
760 cloth constant.

CONSTRUCTION CALCULATIONS

The number of warp ends and of filling picks per square inch, that is, the sley and the pick, are often referred to as the "construction" of the cloth.

Staple plain cloths with a large number of ends per inch are made with fine yarns, and the coarser the yarn the fewer threads used per square inch. The same yarns may be used in different construction, however, according to the openness of the fabric desired. There is a limit, depending on the diameter of the yarn, to the number of ends of any count that can be used but the fabric can be made as open as desired and in some instances fine yarns are used in very coarse constructions.

In plain cloths for ordinary purposes it is usually found best to have the sley and pick approximate to secure best results. In the United States it is customary to have the sley slightly exceed the pick. In England it would seem that the contrary is the case, that there are usually slightly more picks than ends. If the sley and pick are the same the cloth is said to have a "square" construction. There are certain constructions for certain goods that are more or less standard in each country. For instance in the United States the typical construction for coarse sheeting is 48 square (48 ends and 48 picks per square inch), but sheetings of different qualities are made from as coarse as 40x40 up to 68x68. The typical print cloth construction is 64 square, though subcount prints may be as open as 48x48 in some cases, while fine prints may run up to 88x88 or even above. Some tobacco cloths are made in constructions as coarse as 8x8 ends per square inch while some imported transparent

Swiss organdies or fine French lawns, for women's collars, come in constructions as fine as 180x180. The first has 16 and the latter 360 threads per square inch; these probably mark the limits in staple plain cloths.

In passing it may be noted that while canvas and duck have comparatively coarse constructions they probably average finer in construction as compared with the size of their yarns than any other type of cloths. In some instances they have as many ends in the warp as the count of the yarn would permit to be contained in an inch if laid side by side without any filling; they are packed together so tight in weaving on a heavy loom that there are practically no interstices between the yarns, and the cloth therefore has a board-like feel.

It may also be noted that special fabrics often have more threads per inch than are here noted for plain cloths. For instance, an imported English pique vesting, made with filling back and filling stuffing, has been found on examination to have over 800 threads per square inch. Even plain-woven cloths, if for special purposes, may be far from having approximately the same number of ends and picks per inch, for instance a typical "cord fabric" that is one of the several types of cloths that are used in various parts of an automobile tire, has 2½ picks per inch to 26½ ends per inch. This study, however, is confined mainly to staple plain cloths of large consumption and peculiar specialties may be disregarded.

To find the total threads per square inch, knowing all other particulars:

RULE 26: *Multiply average yarn count by*

cloth constant; divide product by width in inches and by yards per pound.

The above may be expressed, by transposition of the basic formula 1, as

FORMULA 4: $T = \frac{AC}{BY}$

EXAMPLE: A print cloth is to be made 38½ inches wide, to weigh 5.35 yards per pound, from 30s warp and 40s filling. Average yarn count 33.8 and cloth constant 756. What would be total threads per square inch necessary?

ANSWER:

$$T = \frac{AC}{BY} = \frac{33.8 \times 756}{38.5 \times 5.35} = 124 \text{ threads per square inch.}$$

Knowing the usual constructions for print cloths we would naturally make this cloth with 64 warp ends and 60 picks per inch.

WIDTH CALCULATIONS

Woven goods of 12 inches and under are known as narrow fabrics and are made on narrow-fabric or ribbon looms that weave several at a time with the aid of rack-and-pinion controlled shuttles. Cloth is made on an ordinary fly-shuttle loom.

Cloth widths run from 13 inches up to wide sheeting widths of 108 inches; a small amount is made for special purposes in even wider widths. The width is usually stated in inches but for wide sheeting is often expressed in quarters of a yard (9 inches), thus we see quotations on 6/4 (this is 54 inches and known as six-quarter) sheeting up to 12/4 or 108 inch sheeting. Sometimes this system is used for widths less than 50 inches, for instance 4/4 being used in place of 36 inches, or even 3/4 in place of 27 inches.

Ordinary staple cloths are mainly between 25 and 45 inches in width, probably the bulk being between 36 and 40 inches.

Looms are ordinarily known by the width of the cloth that can be woven on them and in order to allow for contraction the reed space is therefore usually four or five inches wider than the nominal width named. For instance a 40″ loom is one intended for weaving cloth up to the 40 inch width and therefore usually has a reed space of 44 to 45 inches.

To find width of cloth to correspond with other particulars stated:

RULE 27. *Multiply average yarn count by cloth constant; divide product by total threads per square inch and by yards to the pound.*

The above may be expressed, by transposition of the basic formula 1, as

FORMULA 5: $B = \dfrac{AC}{TY}$

EXAMPLE: A sub-count print cloth is to be made with 64 ends of 28s warp and 56 picks of 38s filling. Weight desired is 7.85 yards per pound. Average yarn count is 33.6 and cloth constant 756. What would be the necessary width of the cloth?

ANSWER:

$$B = \frac{AC}{TY} = \frac{33.6 \times 756}{120 \times 7.85} = 27 \text{ inches.}$$

RELATION OF CLOTH WIDTH AND WEIGHT.

If the warp and filling yarns, also the sley and pick, are maintained the same then the width times the weight is constant.

To find weight corresponding to a new width, yarns and construction being unchanged:

RULE 28: *Multiply present width and weight together for a constant. Divide this constant by any desired width and the quotient will be the corresponding weight.*

EXAMPLE: A 36-inch, 64x68, 21s.24s, sheeting weighs 3.50 yards. What would be the weight of identical cloth in other usual widths?

ANSWER: $36 \times 3.50 = 126$. Dividing this constant by various widths we get corresponding

weight in yards per pound as follows:

30	inch	width	weighs	4.20	yards	per	pound.
32	"	"	"	3.94	"	"	"
34	"	"	"	3.71	"	"	"
36	"	"	"	3.50	"	"	"
38	"	"	"	3.32	"	"	"
40	"	"	"	3.15	"	"	"
42	"	"	"	3.00	"	"	"
45	"	"	"	2.80	"	"	"
48	"	"	"	2.62	"	"	"
54	"	"	"	2.33	"	"	"
63	"	"	"	2.00	"	"	"
72	"	"	"	1.75	"	"	"
81	"	"	"	1.55	"	"	"
90	"	"	"	1.40	"	"	"
99	"	"	"	1.27	"	"	"
108	"	"	"	1.17	"	"	"

WEIGHT CALCULATIONS

In the United States the weight of cloth is usually stated in terms of the linear yards that weigh one pound. Heavy goods such as duck and tire fabrics are more conveniently stated in terms of ounces per yard, in order to avoid fractions. The English use an entirely different system from either of these, as they usually state the weight in terms of pounds per piece of so many yards. For certain purposes cloth is stated in terms of square yards to the pound; this system has also been used in tariff laws.

Let $Y =$ yards (linear) per pound.
$Z =$ ounces per linear yard.
$S =$ square yards per pound.
$L =$ lbs. per piece.

To find weight in linear yards per pound, knowing ounces per linear yard:

RULE 29: *Divide* 16 (*ounces to pound*) *by ounces per linear yard.*

EXAMPLE: A tent duck weighs 10 ounces per linear yard. What is the weight in yards per pound?

ANSWER: $Y = \frac{16}{Z} = \frac{16}{10} = 1.6$ yards per lb.

NOTE—In the same way yards per pound can be changed to ounces per yard by dividing 16 by the yards per pound.

To find weight in square yards per pound, knowing linear yards per pound:

RULE 30: *Multiply width in inches by yards per pound and divide by 36.*

EXAMPLE 1: A 38½-inch print cloth measures 5.35 linear yards per pound. How many square yards to the pound?

ANSWER:

$$S = \frac{BY}{36} = \frac{38.5 \times 5.35}{36} = 5.72 \text{ square yds. per pound.}$$

EXAMPLE 2: A 27 inch print cloth measures 7.85 linear yards per pound. How many square yards to the pound?

ANSWER:

$$S = \frac{BY}{36} = \frac{27 \times 7.85}{36} = 5.89 \text{ square yards per pound.}$$

NOTE—In the same way, square yards to the pound times 36, divided by the width, gives yards per pound.

To find weight in pounds per cut, knowing yards per pound:

RULE 31: *Divide length of cut in yards by the yards per pound.*

EXAMPLE: What is weight of a 40 yard cut of 2.85-yard drill?

ANSWER:

$$L = \frac{40}{Y} = \frac{40}{2.85} = 14 \text{ pounds per cut.}$$

To find weight in yards per pound, knowing weight in pounds per piece:

RULE 32: *Divide yards per piece by weight of piece in pounds.*

EXAMPLE: The standard English grey shirting is known as the "8¼-lb. shirting" and measures 38 yards to the piece. What is the weight in yards per pound?

ANSWER:

$$Y = \frac{38}{L} = \frac{38}{8\frac{1}{4}} = 4.12 \text{ yards per pound.}$$

To find weight of cloth in yards per pound, knowing all other particulars:

RULE 33: *Multiply the average yarn count by cloth constant; divide the product by the width in inches and by the total threads per square inch.*

The above may be expressed, by transposition of the basic formula 1, as

FORMULA 6: $Y = \frac{AC}{BT}$

EXAMPLE: A print cloth is made 38½ inches, 64x64, 30s.38s. Average yarn count 33.6, and cloth constant 756. What is weight in yards per pound?

ANSWER:

$$Y = \frac{AC}{BT} = \frac{33.6 \times 756}{38.5 \times 128} = 5.15 \text{ yds. per lb.}$$

To find weight of cloth in yards per pound, knowing all other particulars:

RULE 34: *Divide the sley by the warp count;*

divide the pick by the filling count; add their quotients and multiply by the width. Divide the cloth constant by the result.

The above may be expressed as follows:

$$Y = C \div B\left(\frac{E}{W} + \frac{P}{F}\right)$$

EXAMPLE: A print cloth is made 38½ inches, 64x64, 30s.38s. Cloth constant 756. What is weight in yards per pound?

ANSWER:

$$Y = 756 \div 38.5\left(\frac{64}{30} + \frac{64}{38}\right) =$$

$$\frac{756}{38.5 \times 3.817} = 5.15 \text{ yards per pound.}$$

PERCENTAGES OF WARP, FILLING, AND SIZING

To find weight of filling yarn in a piece of cloth, knowing all particulars:

RULE 35: *Multiply width in reed by picks per inch and by yards cloth in piece; divide product by the filling count and by* 840.

EXAMPLE: A print cloth is woven 39 inches, 72x76, 30s.38s, 4.25 yds. per lb. What is weight of filling in a 60-yard cut?

ANSWER: Assuming a cloth constant of 756 then from Rule 17 the average yarn count would be 32½s. The filling contraction is found from the table given for the contraction on plain cloth by looking under the column headed 72 (in this case ends warp crossed by the filling) and taking a figure that is one-fourth of the difference between those shown for 32s and 34s average yarn counts; for 32½s average yarn count the filling contraction is therefore 8.3%. The cloth width, 39 inches, divided by 1 minus 8.3%, which is .917, gives width in reed as 42½ inches.

Then the weight filling in cut =

$$\frac{42.5 \times 76 \times 60}{38 \times 840} = 6.07 \text{ lbs.}$$

To find weight of warp (unsized) in a piece of cloth, knowing all particulars:

RULE 36: *Divide total ends in warp by* 1 *minus warp contraction to get yards warp yarn in one*

yard of cloth; multiply this by yards in piece and divide by the warp count and by 840.

EXAMPLE: (As above). What is the weight of warp (unsized) in a 60-yard cut?

ANSWER: Total ends in warp = 39 × 72 = 2808 plus 48 selvage ends = 2856. From the warp contraction table we find under the column headed 76 (in this case picks crossed by the warp) that the warp contraction corresponding to 32½s average yarn count would be 9.1%. 1 minus 9.1 = .909.

Then weight unsized warp in cut =

$$\frac{2856}{.909} \times \frac{60}{30 \times 840} = \frac{3142 \times 60}{30 \times 840} = 7.48 \text{ lbs.}$$

To find weight of sizing in a piece of cloth, knowing all particulars:

RULE 37: *Add weight of filling, ascertained by Rule* 35, *to weight of unsized warp, ascertained by Rule* 36, *and subtract from total weight of cloth.*

EXAMPLE: (As above). What is the weight of the sizing in a 60-yard cut?

ANSWER: A 60-yard cut of 4.25 yard cloth weighs 60 ÷ 4.25 = 14.12 lbs. Weight of filling plus unsized warp = 6.07 + 7.48 = 13.55 lbs. Weight of sizing in cut therefore 14.12 = 13.55 = 0.57 lb.

To find percentages of filling, warp (unsized), and sizing in a piece of cloth, having their respective weights:

RULE 38: *Divide weights of filling, of unsized warp, and of sizing by weight of the piece to get their respective percentages.*

EXAMPLE: (As above.) What are percentages of warp, of filling, and of sizing?

ANSWER: As the cut weighs 14.12 lbs. and the filling 6.07 lbs., the filling constitutes 6.07 divided by 14.12 or 43% of the total weight. Similarly we find the unsized warp to constitute 7.48 divided by 14.12 or 53%, while the sizing constitutes 0.57 divided by 14.12 or 4% of the total weight of the cloth.

To find percentage of sizing on warp, knowing percentage sizing in cloth:

RULE 39: *Divide percentage of sizing in cloth by percentage of warp yarn in cloth.*

EXAMPLE: A cloth as woven is composed of 43% filling, 53% unsized warp, and 4% sizing. What is percentage of sizing on warp?

ANSWER: If the sizing constitutes 4% of the total weight of the cloth and the warp yarn constitutes 53%, then there are 4 pounds of sizing to every 53 pounds of warp yarn. 4 divided by 53 gives 7½% of sizing on warp. Allowing for amount shaken and chafed off in weaving there must have been at least 8% sizing added to the weight of the warp yarn at the slasher.

To find approximate percentage of filling and of sized warp, knowing width, sley, pick, and yarn counts:

RULE 40: *Divide total number of ends in the*

warp by the warp count to obtain relative weight of warp. Multiply picks per inch by width and divide by filling count to obtain relative weight of filling. Divide weight of warp by sum of weights of warp and filling to obtain percentage of sized warp. Divide weight of filling by sum of weights of warp and filling to obtain percentage of filling.

EXAMPLE: A 4-yard sheeting is woven 36 inches, 52x48, 17s.21s. What are the percentages of warp (sized) and filling in the cloth?

ANSWER: Total ends in warp $= 36 \times 52 = 1872$ plus 48 selvage ends $= 1920$. $1920 \div 17 = 112.9$ relative weight of warp.

$$\frac{48 \times 36}{21} = 82.3 \text{ relative weight of filling.}$$

$112.9 + 82.3 = 195.2$ weight of warp and filling.

Then $112.9 \div 195.2 = 57.8\%$ warp (sized).
$82.3 \div 195.2 = 42.2\%$ filling.

To find approximate percentage of filling and of sized warp, knowing sley, pick, and yarn counts:

RULE 41: *Divide sley by warp count, and pick by filling count to obtain relative weights of warp and filling. Divide each by their sum to obtain percentages of warp and filling.*

EXAMPLE: What are approximate percentages of warp and filling in a cloth made with 52 ends of 17s and 48 picks of 21s to the square inch?

ANSWERS

$52 \div 17 = 3.06$ relative weight of sized warp.
$48 \div 21 = 2.28$ relative weight of filling.

$3.06 + 2.28 = 5.34$ weight of warp and filling.
Then $3.06 \div 5.34 = 57.3\%$ sized warp.
$2.28 \div 5.34 = 42.7\%$ filling.

To find approximate percentage of sized warp, knowing sley, pick, warp count, and average yarn count:

RULE 42: *Multiply sley by average yarn count; divide product by warp count and by total threads per square inch.*

Expressed as a formula this is EA $\div$ WT.

EXAMPLE: A pajama check is made with 72x80 ends per square inch; the warp count is 30s and the average yarn count 34.9s. What is percentage of sized warp in the cloth?

ANSWER: Percentage of sized warp =

$$\frac{EA}{WT} = \frac{72 \times 34.9}{30 \times 152} = 55\%.$$

NOTE—The percentage of filling, from above, would therefore be $100 - 55 = 45\%$. If, however, the problem had been to find the percentage of filling, knowing sley, pick, average yarn count, and filling, the latter being given as 41s, then we would have proceeded as follows:

$$\text{Percentage filling} = \frac{PA}{FT} = \frac{80 \times 34.9}{41 \times 152} = 45\%.$$

SELE TION OF YARN COUNTS TO MAKE A CERTAIN CLOTH

To find suitable yarn counts when width, weight and construction of cloth are gievn:

RULE 43: (a) *Ascertain average yarn count by Rule 17, assuming an approximate cloth constant from knowledge of similar goods.* (b) *Decide on a warp count, not too far removed from the average yarn count, that fits best into the mill organization. Also decide on percentage of size preferred on warp.* (c) *Ascertain weight of sized warp in a convenient length of cloth, say 100 yards.* (d) *Find weight of filling, for same length of cloth, by subtracting weight of sized warp from weight of cloth.* (e) *The filling count is then found by multiplying width in reed by picks per inch and by length of cloth, and dividing by 840 and by weight of filling.*

EXAMPLE: A mill receives an order for 36 inch, 56x60, 4-yard sheeting. The problem to be solved is as to the warp and filling yarns to be used.

ANSWER: (a) From experience with similar sheetings we may take 745 as approximately correct for the cloth constant. Then the average yarn count =

$$A = \frac{BYT}{C} = \frac{36 \times 4 \times 116}{745} = 22.4s.$$

(b) In most instances the warp count is coarser than the filling and therefore coarser than the average yarn count. In this instance we may decide on 21s warp as best fitting into the existing

organization and for the same reason decide on 6% sizing to be put on the warp.

(c) Before finding weight of sized warp it is necessary to find the length of warp from the slasher required to make a certain length of cloth. Turning to the table given for contraction on plain cloths and looking under the column headed 60 (in this case picks crossed by the warp) it is seen that average yarn counts of 22s and 24s show contractions of 8.5% and 7.8% respectively and by interpolation the warp contraction corresponding to 22.4s average yarn count would be 8.36%. 1 — 8.36% = .9164. 100 divided by 91.64 gives 109.12 as yards from slasher required to produce 100 yards of cloth. The total ends in warp equal 36 inches times 56 sley, or 2106, plus 40 selvage ends, or 2056 ends total. Then weight of sized warp in 100 yards cloth =

2056 ends × 109.12 yds. warp × 1.06 for sizing
÷ 21s warp yarn × 840 yds. in hank
= 13.48 pounds.

(d) Weight of 100 yards of 4-yard cloth = 100 divided by 4 = 25 lbs. 25 — 13.48 = 11.52 lbs. filling.

(e) From the table given for contraction on plain cloths and under the column headed 56 (in this case ends warp crossed by the filling) we find by interpolation that 22.4s average yarn count would give 7.38% filling contraction. 1 — 7.38 = .9262. .9262 × 56 sley, divided by 2 ends to the dent, gives a reed of 25.93 dents to the inch. As reeds are rarely graded closer than half a dent it is necessary to use a 26 dent reed. Using a 26 dent reed the corrected filling contraction will be 56 minus 52, divided by 56, or 7.14%. 1 — 7.14% = .9286. The cloth width, 36 inches, divided by

.9286, gives width in reed as 38.77 inches. Then filling yarn required =
38.77 width in reed × 60 picks × 100 yds. cloth ÷ 840 yards in hank × 11.52 lbs. filling = 24s.

NOTE—The fact that 21s warp and 24s filling have been proved above to be suitable yarns to use in making this cloth does not mean that they constitute the only yarn combination that can be employed. In fact scarcely any two mills use exactly the same counts and reports from seven Southern mills that regularly employ all or part of their looms in making what is sold as 36 inch, 56x60, 4-yard grey sheeting show the following yarn combinations: (1) 20s.24s, (2) 20½s.23½s, (3) 21s.23s, (4) 21s.24s, (5) 22s.20½s, (6) 22s.22s, (7) 22s.25s. Doubtless other mills employ still other yarns.

There are various reasons for the use of different yarns in making the same fabric. In many instances it is a case of convenience for it is to the interest of the mill to spin as few yarns as possible and if a mill is using 22s warp in making other cloths it may prove more economical to use 22s instead of 21s warp for this cloth also and in such case the filling would have to correspond to obtain the weight desired. The same is true as to the sizing and some mills size much heavier than others. Varying the percentage of sizing changes the center of gravity, that is, the average yarn count, and permits of a different yarn combination. On automatic looms the yards of filling that can be put on a quill is not so important but in the case of non-automatic looms the finer the filling that can be used to obtain the desired result the better, as a longer length of filling on the quill means better production because of fewer

changes of filling, and this fact is frequently a matter for consideration. On the other hand, having the warp slightly finer than the filling means that after sizing the two yarns will be more nearly uniform in diameter and this has its effect on the appearance of the cloth.

The fact also has to be considered that the cloth is not always made exactly to the nominal specifications. Even where this is attempted the fact that it is impossible to spin exactly to count, impossible to put exactly the same percentage of size on every cut, and impossible to use exactly the same tension on every loom so as to have the width invariable, is recognized in the trade to permit of a certain latitude. Advantage is taken of this leeway by some mills and the width, weight, or even the construction may regularly be run on the scant side of the nominal specifications. The extent to which this is allowable, however, depends largely on the nature of the trade to which the mill caters and some mills find it preferable to gain a reputation for their cloth by making it so that it will always average fully up to specifications or even slightly over in width.

It is seen that in the selection of counts to make this cloth there are various factors, outside of the simple calculations, to be considered and not only in this but in the case of other cloths, no matter how standard, there will be found differences from mill to mill. As an illustration take the case of the standard 38½ inch, 64x60, 5.35-yard print cloth which is most typical of the American industry today. A large number of mills use 30s warp and 40s filling but among other combinations in actual use are to be found the following: (2) 28s.38s, (3) 28s.40s, (4) 28s.42s, (5) 28s.44s,

(6) 28½s.40½s, (7) 29s.38s, (8) 29s.42s, (9) 29½s.39s, (10) 30s.38s, (11) 30s.41s, (12) 30s.42s. As a further illustration consider the leader in the tobacco cloth constructions, which is variously known as tobacco cloth, shade cloth, gauze cloth, cotton bandage cloth, and bunting, the 38½ inch, 44x40, 8.20-yard goods that are made in large quantities in many mills. For cloth made to nominally the same specifications we find mills employing, among others, the following yarn combinations: (1) 28s.42s, (2) 29s.44s, (3) 29s.39s, (4) 29s.40s, (5) 29s.42½s, (6) 29½s.41s, (7) 30s.40s, (8) 30s.41s, (9) 30s.43s, (10) 30s.44s.

Assuming that the average mill attempts to make cloth as near as possible to the specifications stated on its order and invoice it would seem, from a study of the yarn variations used in making the above and many other cloths, that, even allowing for the matter of convenience in fitting the manufacture of a particular cloth into the work of a mill making other cloths, many mills do not give the subject of yarn selection as much attention as it deserves. Certain it is that the correct selection of yarn counts is a matter that in itself often gives one mill an advantage over others, though this may be manifested in the obtainment of a better price for a better quality or in more economical cost of production.

Incidentally it may be noted that the spread in the range between the warp and the filling counts usually increases with the fineness of the yarns. In ordinary staple sheetings the warp may be the same or a few numbers coarser than the filling, in ordinary print cloths the warp is usually 4 to 16 counts coarser than the filling, whereas in staple

fine plains the warp may be 15 to 50 or more counts coarser than the filling. (For instance heavy sheetings are largely 12s to 14s warp and 13s to 17s filling, print cloths are largely 28s to 30s warp and 38s to 44s filling, whereas India linons are largely 60s warp and 80s to 130s filling.) In some classes of goods the filling is regularly coarser than the warp but this obtains more largely in goods that are more or less specialties such as blankets, flannelets, Canton flannel, repp, and tapestries.

GREY CLOTH ANALYSIS

Mills engaged in export trade are often asked to weave cloth "to sample," and this occurs not infrequently in the domestic trade. The sample may be of any size but in many instances the mill is furnished only a small clipping and has to ascertain all particulars therefrom.

In analyzing a sample for cloth duplication we may proceed in the following order: (1) Description and weave, (2) width, (3) construction, (4) weight, (5) yarn counts and sizing, (6) reed and slashing length.

In order to show the method of analysis with the greatest clearness we will here confine ourselves to the analysis of plain grey cloth, though the basic system is the same for fancy cloths. We will first discuss the analysis of a small clipping and then of a large sample.

Analysis of a Small Clipping

(1) *Description and Weave.* The class of cloth and the weave are found by inspection. In this instance we will suppose that the sample is that of a plain grey print cloth.

(2) *Width.* In the case of a small sample for cloth duplication the customer specifies the width desired, and also usually the length of cut. In this case we will say that the cloth is desired in 38½-inch width and in 60-yard cuts.

(3) *Construction.* The ends and picks per square inch are ascertained with a pick counter. If the clipping is without selvage ends close inspection is sometimes necessary to decide which is warp and which filling. In most instances, supposing the cloth is not back starched, the warp is easily identified by the fact that it carries sizing whereas the filling does not; the warp is also usually harder twisted than the filling.

(4) *Weight.* The sample is cut to rectangular shape along warp and filling threads and weighed, using a balance that will weigh to the fraction of a grain. The larger the sample that can be cut the more accurate the determination of the weight of the cloth.

To find, from a small sample, the weight of the cloth in yards per pound:

RULE 44: *Multiply square inches in sample by 7,000 (grains per pound); divide product by 36, by width of cloth in inches, and by weight of sample in grains.*

This rule can be shortened as follows:

Multiply square inches in sample by 194.4; divide product by width of cloth in inches and by weight of sample in grains.

EXAMPLE: A sample cut 4 by 4 inches, having an area of 16 square inches, weighs 15.1 grains.

Supposing the cloth is desired in $38\frac{1}{2}$-inch width, what would it weigh in yards per pound?

ANSWER: $$\frac{16 \times 194.4}{15.1 \times 38.5} = 5.35 \text{ yds. per lb.}$$

NOTE—For cloth widths that will divide into 194.4 without remainder the above rule can be shortened. For instance Rule 44 may be used as follows: Divide square inches in sample by weight of sample in grains. Multiply quotient by 5.4 for 36-inch cloth, or 4.86 for 40-inch cloth, to get weight in yards per pound.

To find, from a small sample, the weight of the cloth in ounces per linear yard:

RULE 45: *Multiply weight of sample in grains by* 36 *and by width of cloth; divide product by square inches in sample and by* 437.5 (*grains per ounce*).

EXAMPLE: A sample containing 16 square inches weighs 15.1 grains. What is weight in ounces of a linear yard $38\frac{1}{2}$ inches wide?

ANSWER: $$\frac{15.1 \times 36 \times 38.5}{16 \times 437.5} = 2.99 \text{ ounces per linear yard.}$$

To find, from a small sample, the weight of the cloth in ounces per square yard:

RULE 46: *Multiply weight of sample in grains by* 1296 (*square inches in a square yard*); *divide product by square inches in sample and by* 437.5 (*grains per ounce*).

EXAMPLE: A sample containing 16 square

inches weighs 15.1 grains. What is weight of a square yard in ounces?

ANSWER: $$\frac{15.1 \times 1296}{16 \times 437.5} = 2.80 \text{ oz. per sq. yd.}$$

(5) *Yarn Counts and Sizing.* The yarn count is the number of 840-yard hanks that weigh one pound (7,000 grains). Therefore the number of yards that weigh 8 1/3 grains equals the count; and the number of lengths of 4.32 inches each that weigh one grain equals the count. The count is also found by dividing any number of yards by their weight in grains and by .12.

Comparing yarns with others of known size to determine the count is a very crude method that has no value except for rough approximations. The correct yarn count can be found only by measuring and weighing.

A ready method of ascertaining the yarn counts is afforded by a Universal Yarn Assorting Balance and the template, about 2⅜ inches square, that goes therewith. The sample is cut to template size and the scale is so adjusted that the number of threads from the cut sample that it takes to balance the arm indicates direct the count of the yarn being weighed.

Another ready method is based on the fact that the count is equal to the number of lengths of 4.32 inches each that weigh one grain. If 64 lengths of 4.32 inches each weigh one grain the count is 64s; if 64 lengths of 4.32 inches weigh 2 grains the count is 32s, etc. The method of procedure can be stated as a rule.

To find from a small sample, the yarn counts in condition in cloth:

RULE 47: *Cut sample* 4.32 *inches by* 4.32 *inches*. Unravel one inch width of the warp yarns, smooth to remove the waviness caused by weaving and again cut to 4.32 inch length; do the same with the filling yarns. The warp count (sized) is equal to the ends per inch divided by the weight in grains of this number of warp threads each 4.32 inches long. The filling count is equal to the picks per inch divided by the weight in grains of this number of filling threads each 4.32 inches long.

EXAMPLE: A sample shows 64 ends and 60 picks per square inch. 64 ends, each 4.32 inches long, weighs 2.45 grains. 60 picks, each 4.32 inches long, weighs 1.45 grains. What are the yarn counts?

ANSWER: The warp count (sized) = 64 divided by 2.45 = 26.1s. The filling count = 60 divided by 1.45 = 41.4s.

NOTE—To obtain the spun count of the warp the 64 ends, each 4.32 inches long, can be stripped of size by boiling and reweighed. Suppose they weigh, with allowance for natural moisture, 2.3 grains. Then the spun count would be 64 divided by 2.3 or 27.8s. Allowing for the margin of error in obtaining grain weights of such short lengths we can consider that the warp was originally 28s and the filling, say, 42s. If the sized weight of the warp is 2.45 grains and the unsized weight 2.3 grains, the percentage of sizing on warp is 2.45 minus 2.30, divided by 2.30, or around 6½%.

Stripping. The size is removed by boiling the yarn in a weak solution of soda, or steeping in a weak solution of acid, followed by rinsing in clean

water and drying. In drying the yarn is put in a glass jar or bottle which is placed in an oven. It is preferable to use a small drying oven to which is attached a thermometer and to bring the temperature up to 212 degrees. On removing the bottle, sufficient time should be allowed for cooling, and the yarn then extracted with pincers (to avoid moisture from the hands), and weighed. This gives the bone dry weight, to which is added 7.834% to bring the yarn up to its natural condition with 8½% moisture contents.

(6) *Reed and Slashing Length.* Having obtained the width, weight, and yarn counts, the average yarn count can be ascertained from Rules 17 or 21. The contraction in warp and in filling during weaving can then be found direct from the table given for contraction percentages in weaving plain cloths. Having the contractions the width in reed, and the reed required, also the slashing length, can be obtained by simple calculation according to the rules previously given under those heads.

Analysis of a Large Sample

(1) *Description and Weave.* We will assume that, as before, inspection shows sample to be of plain grey print cloth.

(2) *Width.*. In measuring the width care should be taken to get the full width intended without undue stretching. Width is found to be 38½ inches.

(3) *Construction.* The ends and picks per square inch are ascertained, as before, with a pick counter. The total ends in warp should be counted for exact accuracy or else the selvage ends

counted and added to the product of the sley times the width inside of selvage. We will suppose, as before, that the construction is 64x60. The total ends in warp are found to be 2500.

(4) *Weight.* One full yard, or more if available, should be accurately weighed, and the weight in yards per pound found by dividing 7,000 by the weight of one linear yard in grains. If one yard weighs 1,308 grains then the cloth weighs 5.35 yards to the pound.

(5) *Yarn Counts and Sizing.* Unravel one inch, 60 picks, of filling and weigh; suppose this comes to 13.85 grains. If there are 60 picks per inch there are 60×36 or 2160 picks per yard and therefore the weight of the filling in a linear yard $= 13.85 \times 2160$ divided by $60 = 498$ grains. As the weight of the cloth equals 1308 grains, the weight of the sized warp in a linear yard equals 1308 minus 498, or 810 grains.

To obtain the length of filling pull out four continuous picks, place two of the loops, made by the shuttle in reversing, around a pin stuck in the edge of a table and carefully pull the other ends to remove the waviness caused in weaving, taking care to avoid undue elongation of the yarn. Suppose the length of pick is found to have been 41.2 inches then the length of filling in a linear yard equals 2160 times 41.2 divided by 36, or 2472 yards.

To obtain the length of warp used pull out a couple of ends and carefully stretch to remove the waviness caused by weaving. Suppose the length is found to be 38.3 inches then the total length of warp in a linear yard of the cloth equals 2500 (total ends) times 38.3 divided by 36, or 2660 yards.

The count of any yarn can be found by dividing the length in yards by the weight in grains times .12. Therefore from above the filling count would be 2472 divided by 498 and by .12, or 41.3s. The warp count (sized) would be 2660 divided by 810 and by .12, or 27.3s.

The original spun count of the warp and the percentage of sizing can be ascertained, as in the case of the small clipping, by boiling to remove the size and again weighing.

(6) *Reed and Slashing Length.* The length of the pick, which is the same as the width in reed, has been found under (5) to be 41.2 inches, and the filling contraction is therefore 41.2 minus 38.5 divided by 41.2 or 6.55%. 1 — 6.55% = .945. If there are 64 ends per inch in the cloth the reed required is 64 times .945 divided by 2, or 30.14, say 30, dents per inch.

Under (5) above it was found that 38.3 inches, equal to 1.064 yards, of warp yarn was contained in each 36-inch length as measured in the cloth. For 100 yards of cloth there would be required 106.4 yards of warp, and for a 60-yard cut of cloth there would be required 60 × 1.064 or 63.84 yards of warp from the slasher.

PRODUCTION PROBLEMS.

In almost any weave shed, but particularly in those making a variety of goods, production problems are constantly coming up for solution, and in order to make the best use of the available looms these have to be solved intelligently and in many cases quickly. The main problem of course is as to the output that can be expected of a loom on a certain cloth, this being essential in fixing the rate per cut as well as in knowing how many looms

to allocate to a certain order in order to finish it on time. Closely allied to production problems are those relating to the amount of warp and filling that will be required from week to week to keep loom production up to standard.

Cloth Production.

The yards of cloth produced per loom depend on the picks per inch, the picks per minute, and the time the loom is in actual operation. Theoretical or 100% production is, of course, never attained in practice for there is more or less loss of time in piecing up broken ends and, in the case of non-automatic looms, in changing shuttles; the loom also stands while the loom fixer is making adjustments or repairs, and while warps are being renewed. The amount of time lost depends on many factors such as the nature of the goods, the speed of the looms, the quality of the material, the skill of the weaver, the efficiency of the loom fixer, and the character of the management, so that there is a wide variation from mill to mill or even between two weavers in the same alley.

The following percentages of full time production may be taken as indicative of good practice:

85 to 95% production on automatic plain looms.
80 to 90% production on plain looms.
80 to 90% production on automatic looms with dobbies.
75 to 85% production on drop-box looms.
70 to 80% production on drop-box dobbies.
60 to 70% production on Jacquards.

There are some mills that attain a better production than the normal maximums stated but there are a large number that for various reasons fall under the normal minimums given.

To find 100% production (no allowance for stops), in 60 hours:

RULE 48: *Multiply picks per minute by* 100 *and divide by picks per inch.*

EXAMPLE: A loom on 36 inch, 48x48, 3-yard sheeting is run at 180 picks per minute. What is theoretical or 100% production in 60 hours?

ANSWER: $\dfrac{180 \times 100}{48} = 375$ yards.

NOTE—This is a very convenient rule to remember as a basis, even though mills no longer work 60 hours. Knowing 100% production in 60 hours, 100% production in any other period of time can be obtained by proportion. Thus 100% production in 55 hours $= 11/12$ times $375 = 343.75$ yards, and 100% production in 48 hours $= .8 \times 375 = 300$ yards, since 55 hours is eleventh-twelfths and 48 hours is eight-tenths of 60 hours.

To find 100% production (no allowance for stops), in any number of hours:

RULE 49: *Multiply picks per minute by total minutes weave shed is run; divide product by picks per inch and by* 36.

EXAMPLE: A loom on 48 pick goods is run at 180 picks per minute. What is 100% production in a full-time week of 55 hours?

ANSWER: $\dfrac{180 \times 60 \times 55}{48 \times 36} = 343.75$ yards.

To find yards woven per loom per week:

RULE 50: *Multiply picks per minute by* 60 (*minutes in hour*), *by full-time hours, and by per cent of theoretical production attained; divide product by picks per inch and by* 36 (*inches in yard*).

EXAMPLE: A loom on 38½ inch, 44x40, 8.20-yard tobacco cloth is run at 174 picks per minute. What is 85% production in a full time week of 55 hours?

ANSWER: $$\frac{174 \times 60 \times 55 \times .85}{40 \times 36} = 338.9 \text{ yds.}$$

To find cuts of cloth woven per loom per week:

RULE 51: *Multiply picks per minute by* 60, *by full-time hours, and by per cent of theoretical production attained; divide product by picks per inch, by* 36, *and by yards per cut.*

EXAMPLE: A loom on 40 pick goods is run at 174 picks per minute. How many cuts of 60 yards each are obtained in a week of 55 hours, assuming 85% loom efficiency?

ANSWER: $$\frac{174 \times 60 \times 55 \times .85}{40 \times 36 \times 60} = 5.65 \text{ cuts.}$$

NOTE—Since 60 and 36 are constants it is possible to slightly shorten the two preceding rules by substituting division by .6 in place of multiplying by 60 and dividing by 36.

To find yards woven per loom per week, using constants:

RULE 52: *Multiply picks per minute by the constant desired in the following list and divide by picks per inch.*

Per Cent of Production.	Constant to Use for 48 Hours.	Constant to Use for 55 Hours.	Constant to Use for 60 Hours.
50	40	45.8	50
55	44	50.4	55
60	48	55	60
65	52	59.6	65
70	56	64.2	70
75	60	68.8	75
80	64	73.3	80
85	68	77.9	85
87½	70	80.2	87½
90	72	82.5	90
92½	74	84.8	92½
95	76	87.1	95
100	80	91.7	100

EXAMPLE: A loom on 40 pick goods is run at 174 picks per minute. Assuming production to be 85% of the theoretical, how many yards are woven per week of 55 hours?

ANSWER: $\frac{174 \times 77.9}{40} = 338.9$ yards.

To find yards woven per loom per week, using production table:

RULE 53: *Multiply the* 100% *production shown per loom per hour by hours run and by percentage of theoretical production attained.*

EXAMPLE: A loom on 80 pick goods is run at 165 picks per minute. Assuming production to be 85% of the theoretical, how many yards are woven per week of 55 hours?

ANSWER: According to the table theoretical 100% production per loom per hour would be 3.44 yards, therefore actual production in 55 hours would be $3.44 \times 55 \times .85 = 160.8$ yards.

To find loom efficency when loom speed, picks per inch, and yards woven in a stated time, are known:

RULE 54: *Multiply picks per inch by .6 and by yards woven; divide by picks per minute and by hours run.*

NOTE—The .6 is obtained by dividing 36 (inches per yard) by 60 (minutes in hour).

EXAMPLE: A loom running 136 picks per minute on 60 inch, 60x56, 2.75-yard wide sheeting gets off 190 yards in a week of 55 hours. What is efficiency of loom?

ANSWER: $\dfrac{56 \times .6 \times 190}{136 \times 55} = 85.3\%$ production

To find pounds of cloth produced per loom per week:

RULE 55: *Multiply picks per minute by minutes operated (allowing for stops); divide product by picks per inch, by 36, and by yards per pound.*

EXAMPLE: A loom on 38½ inch, 64x64, 5.15-yard print cloth is changed to 36 inch, 20x16, 21-

yard gauze cloth for surgical dressings. Assuming speed of 170 picks per minute and production of 85% to be the same in both cases, what are the relative pounds of cloth produced?

ANSWER: $\dfrac{170 \times 60 \times 55 \times .85}{64 \times 36 \times 5.15} = 40.19$ lbs. of 5.15-yard print cloth

$\dfrac{170 \times 60 \times 55 \times 85}{16 \times 36 \times 21} = 39.42$ lbs. of 21-yd. gauze cloth.

NOTE—The above illustration is reminiscent of war time changes. Many mills that were called on by the Government to change from print cloths to gauze cloths (commonly known as tobacco cloth construction) found that there was practically no change in the yarn counts or in the amounts of yarn required from the spinning room, nor in the pounds of cloth that could be produced if warps were available, but that it was impossible to change over the whole mill to the faster-running gauze cloths because of lack of slasher capacity. While the pounds of warp required might be the same, the fewer ends in the gauze cloth warps meant that two or three times as many yards of warp must be put through the slashers and it was impossible to speed them up to anything like this proportion.

To estimate time required to weave a certain length of cloth.

RULE 56: *Multiply picks per inch by .6 and by yards of cloth desired; divide product by picks per minute and by per cent production estimated.*

EXAMPLE: Loom is running at 160 picks per minute on 39 inch, 68x72, 4.75 yard print cloth. Figuring on 90% production, how long would it take to exhaust a loom beam that holds warp enough for 1,200 yards (20 cuts of 60 yards each) of cloth?

ANSWER: $\dfrac{72 \times .6 \times 1{,}200}{160 \times .90} = 360$ hours, or 6 weeks (of 55 hours) and 3 days.

To estimate looms require to fill an order in a certain time:

RULE 57: *Multiply yards cloth required by .6 and by picks per inch; divide product by picks per minute, by percentage of theoretical production estimated, and by hours allowed for filling order.*

EXAMPLE: A mill accepts an order for 100,000 yards of 39 inch, 68x72, 4.75-yard print cloth to be shipped within 6 weeks. Mill works 55 hours a week and on these goods runs looms at 160 picks per minute, obtaining about 90% production. How many looms should be allocated to this order?

ANSWER: $\dfrac{100{,}000 \times .6 \times 72}{160 \times .90 \times 330} = 91$ looms.

WEAVER'S WAGES

To find weekly wages of a weaver on a particular cloth:

RULE 58: *Multiply total cuts produced by rate of payment per cut.*

EXAMPLE: A weaver tends 12 plain looms, fitted with warp stop motions and running at 160

picks per minute, on 43 inch, 68x76, 30s.36s, 4-yard twill. He is paid 50 cents per cut of 60 yards and gets off 85% production? How much does he make in a 55-hour week?

ANSWER: By Rule 51 the production per set of 12 looms would be

$$\frac{12 \times 160 \times 55 \times .85}{76 \times .6 \times 60} =$$

31.75 cuts total per week. Then his weekly wages $= 31.75 \times \$0.50 = \$15.88$ a week.

To find rate per cut on a new cloth to give equivalent wages per week:

RULE 59: *Ascertain cuts per week obtainable on the new cloth and divide into former wages per week.*

EXAMPLE: A weaver on 12 plain looms is making \$15.88 a week. It is proposed to give him 20 automatic looms, running at 160 picks per minute, on 39 inch, 68x72, 30s.40s, 4.75 yard print cloth. If he is assumed to get off 90% production, how much will he have to be paid per cut of 60 yards to give him approximately the same weekly return?

EXAMPLE: Using Rule 51 the production per 20 looms on the new cloth would be

$$\frac{20 \times 160 \times 55 \times .90}{72 \times .6 \times 60} = 61.11 \text{ cuts total per week.}$$

Then \$15.88 divided by 61.11 = 26 cents per cut.

NOTE: In changing to a cloth where the work is easier so that a weaver is not entitled to as high returns, or to a cloth where more work or

greater skill is required so that the weaver is entitled to a greater remuneration, the same system applies in that the probable cuts per week should be first determined and then divided into the weekly wages that are regarded as fair for the work to be done.

To find weekly wages per loom:

RULE 60: *Divide weekly wages by looms operated.*

EXAMPLE: On 43 inch, 4-yard twill a weaver on 12 plain looms makes $15.88 and on 39 inch, 4.75-yard print cloth a weaver on 20 automatic looms makes $15.88 a week. What is weekly wage cost per loom?

ANSWER: The weekly wage cost per loom is $15.88 divided by 12 or $1.325 on the plain looms and $15.88 divided by 20 or $0.794 on the automatic looms.

To find weaver's wages per pound of cloth:

RULE 61: *Divide rate per cut by pounds per cut.*

EXAMPLE: A weaver on 43 inch, 4-yard twill is paid 50 cents a cut of 60 yards and a weaver on 39 inch, 4.75-yard print cloth is paid 26 cents a cut of 60 yards. How much is paid per pound of cloth:

ANSWER: A 60-yard cut of 4-yard twill weighs 15 pounds and a 60-yard cut of 4.75-yard print cloth weighs 12.63 pounds. On the twill the mill is paying 50 divided by 15 or 3.33 cents a pound, and on the print cloth 26 divided by 12.63 or 2.06 cents a pound, as weaver's wages.

(1)

YARDS OF CLOTH PER LOOM PER HOUR

(100% Production)

Picks per Inch.	PICKS PER MINUTE 100	105	110	115	120	125	130	135	140	145	150
20	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	11.67	12.08	12.50
22	7.58	7.95	8.33	8.71	9.09	9.47	9.85	10.23	10.61	10.98	11.36
24	6.94	7.29	7.64	7.99	8.33	8.68	9.03	9.37	9.72	10.07	10.42
26	6.41	6.73	7.05	7.37	7.69	8.01	8.33	8.65	8.97	9.29	9.62
28	5.95	6.25	6.55	6.85	7.14	7.44	7.74	8.04	8.33	8.63	8.93
30	5.56	5.83	6.11	6.39	6.67	6.94	7.22	7.50	7.78	8.06	8.33
32	5.21	5.47	5.73	5.99	6.25	6.51	6.77	7.03	7.29	7.55	7.81
34	4.90	5.15	5.39	5.64	5.88	6.13	6.37	6.62	6.86	7.11	7.35
36	4.63	4.86	5.09	5.32	5.56	5.79	6.02	6.25	6.48	6.71	6.94
38	4.39	4.61	4.82	5.04	5.26	5.48	5.70	5.92	6.14	6.36	6.58
40	4.17	4.37	4.58	4.79	5.00	5.21	5.42	5.63	5.83	6.04	6.25
42	3.97	4.17	4.37	4.56	4.76	4.96	5.16	5.36	5.56	5.75	5.95
44	3.79	3.98	4.17	4.36	4.55	4.73	4.92	5.11	5.30	5.49	5.68
46	3.62	3.80	3.99	4.17	4.35	4.53	4.71	4.89	5.07	5.25	5.43
48	3.47	3.65	3.82	3.99	4.17	4.34	4.51	4.69	4.86	5.03	5.21
50	3.33	3.50	3.67	3.83	4.00	4.17	4.33	4.50	4.67	4.83	5.00
52	3.21	3.37	3.53	3.69	3.85	4.01	4.17	4.33	4.49	4.65	4.81
54	3.09	3.24	3.40	3.55	3.70	3.86	4.01	4.17	4.32	4.48	4.63
56	2.98	3.13	3.27	3.42	3.57	3.72	3.87	4.02	4.17	4.32	4.46
58	2.87	3.02	3.16	3.30	3.45	3.59	3.74	3.88	4.02	4.17	4.31
60	2.78	2.92	3.06	3.19	3.33	3.47	3.61	3.75	3.89	4.03	4.17
62	2.69	2.82	2.96	3.09	3.23	3.36	3.49	3.63	3.76	3.90	4.03
64	2.60	2.73	2.86	2.99	3.13	3.26	3.39	3.52	3.65	3.78	3.91
66	2.53	2.65	2.78	2.90	3.03	3.16	3.28	3.41	3.54	3.66	3.79
68	2.45	2.57	2.70	2.82	2.94	3.06	3.19	3.31	3.43	3.55	3.68
70	2.38	2.50	2.62	2.74	2.86	2.98	3.10	3.21	3.33	3.45	3.57
72	2.31	2.43	2.55	2.66	2.78	2.89	3.01	3.13	3.24	3.36	3.47
74	2.25	2.36	2.48	2.59	2.70	2.82	2.93	3.04	3.15	3.27	3.38
76	2.19	2.30	2.41	2.52	2.63	2.74	2.85	2.96	3.07	3.18	3.29
78	2.14	2.24	2.35	2.46	2.56	2.67	2.78	2.88	2.99	3.10	3.21
80	2.08	2.19	2.29	2.40	2.50	2.60	2.71	2.81	2.92	3.02	3.13
82	2.03	2.13	2.24	2.34	2.44	2.54	2.64	2.74	2.85	2.95	3.05
84	1.98	2.08	2.18	2.28	2.38	2.48	2.58	2.68	2.78	2.88	2.98
86	1.94	2.03	2.13	2.23	2.33	2.42	2.52	2.62	2.71	2.81	2.91
88	1.89	1.99	2.08	2.18	2.27	2.37	2.46	2.56	2.65	2.75	2.84

(2)

YARDS OF CLOTH PER LOOM PER HOUR
(100% Production)

Picks per Inch.	PICKS PER MINUTE										
	155	160	165	170	175	180	185	190	195	200	205
20	12.92	13.33	13.75	14.17	14.58	15.00	15.42	15.83	16.25	16.67	17.08
22	11.74	12.12	12.50	12.88	13.26	13.64	14.02	14.39	14.77	15.15	15.53
24	10.76	11.11	11.46	11.81	12.15	12.50	12.85	13.19	13.54	13.89	14.24
26	9.94	10.26	10.58	10.90	11.22	11.54	11.86	12.18	12.50	12.82	13.14
28	9.23	9.52	9.82	10.12	10.42	10.71	11.01	11.31	11.61	11.90	12.20
30	8.61	8.89	9.17	9.44	9.72	10.00	10.28	10.55	10.83	11.11	11.39
32	8.07	8.33	8.59	8.85	9.11	9.37	9.64	9.90	10.16	10.42	10.68
34	7.60	7.84	8.09	8.33	8.58	8.82	9.07	9.31	9.56	9.80	10.05
36	7.18	7.41	7.64	7.87	8.10	8.33	8.56	8.80	9.03	9.26	9.49
38	6.80	7.02	7.24	7.46	7.68	7.89	8.11	8.33	8.55	8.77	8.99
40	6.46	6.67	6.87	7.08	7.29	7.50	7.71	7.92	8.13	8.33	8.54
42	6.15	6.35	6.55	6.75	6.94	7.14	7.34	7.54	7.74	7.94	8.13
44	5.87	6.06	6.25	6.44	6.63	6.82	7.01	7.20	7.39	7.58	7.77
46	5.62	5.80	5.98	6.16	6.34	6.52	6.70	6.88	7.07	7.25	7.43
48	5.38	5.56	5.73	5.90	6.08	6.25	6.42	6.60	6.77	6.94	7.12
50	5.17	5.33	5.50	5.67	5.83	6.00	6.17	6.33	6.50	6.67	6.83
52	4.97	5.13	5.29	5.45	5.61	5.77	5.93	6.09	6.25	6.41	6.57
54	4.78	4.94	5.09	5.25	5.40	5.56	5.71	5.86	6.02	6.17	6.33
56	4.61	4.76	4.91	5.06	5.21	5.36	5.51	5.65	5.80	5.95	6.10
58	4.45	4.60	4.74	4.88	5.03	5.17	5.32	5.46	5.60	5.75	5.89
60	4.31	4.44	4.58	4.72	4.86	5.00	5.14	5.28	5.42	5.56	5.69
62	4.17	4.30	4.44	4.57	4.70	4.84	4.97	5.11	5.24	5.38	5.51
64	4.04	4.17	4.30	4.43	4.56	4.69	4.82	4.95	5.08	5.21	5.34
66	3.91	4.04	4.17	4.29	4.42	4.55	4.67	4.80	4.92	5.05	5.18
68	3.80	3.92	4.04	4.17	4.29	4.41	4.53	4.66	4.78	4.90	5.02
70	3.69	3.81	3.93	4.05	4.17	4.29	4.40	4.52	4.64	4.76	4.88
72	3.59	3.70	3.82	3.94	4.05	4.17	4.28	4.40	4.51	4.63	4.75
74	3.49	3.60	3.72	3.83	3.94	4.05	4.17	4.28	4.39	4.50	4.62
76	3.40	3.51	3.62	3.73	3.84	3.95	4.06	4.17	4.28	4.39	4.50
78	3.31	3.42	3.53	3.63	3.74	3.85	3.95	4.06	4.17	4.27	4.38
80	3.23	3.33	3.44	3.54	3.65	3.75	3.85	3.96	4.06	4.17	4.27
82	3.15	3.25	3.35	3.46	3.56	3.66	3.76	3.86	3.96	4.07	4.17
84	3.08	3.17	3.27	3.37	3.47	3.57	3.66	3.77	3.87	3.97	4.07
86	3.00	3.10	3.20	3.29	3.39	3.49	3.58	3.68	3.78	3.88	3.97
88	2.94	3.03	3.13	3.22	3.31	3.41	3.50	3.60	3.69	3.79	3.88

(3)

YARDS OF CLOTH PER LOOM PER HOUR (100% Production)

Picks per Inch.	100	105	110	115	120	125	130	135	140	145	150
	PICKS PER MINUTE										
90	1.85	1.94	2.04	2.13	2.22	2.31	2.41	2.50	2.59	2.69	2.78
92	1.81	1.90	1.99	2.08	2.17	2.26	2.36	2.45	2.54	2.63	2.72
94	1.77	1.86	1.95	2.04	2.13	2.22	2.30	2.39	2.48	2.57	2.66
96	1.74	1.82	1.91	2.00	2.08	2.17	2.26	2.34	2.43	2.52	2.60
98	1.70	1.79	1.87	1.96	2.04	2.13	2.21	2.30	2.38	2.47	2.55
100	1.67	1.75	1.83	1.92	2.00	2.08	2.17	2.25	2.33	2.42	2.50
102	1.63	1.72	1.80	1.88	1.96	2.04	2.12	2.21	2.29	2.37	2.45
104	1.60	1.68	1.76	1.84	1.92	2.00	2.08	2.16	2.24	2.32	2.40
106	1.57	1.65	1.73	1.81	1.89	1.97	2.04	2.12	2.20	2.28	2.36
108	1.54	1.62	1.70	1.77	1.85	1.93	2.01	2.08	2.16	2.24	2.31
110	1.52	1.59	1.67	1.74	1.82	1.89	1.97	2.05	2.12	2.20	2.27
112	1.49	1.56	1.64	1.71	1.79	1.86	1.93	2.01	2.08	2.16	2.23
114	1.46	1.54	1.61	1.68	1.75	1.83	1.90	1.97	2.05	2.12	2.19
116	1.44	1.51	1.58	1.65	1.72	1.80	1.87	1.94	2.01	2.08	2.16
118	1.41	1.48	1.55	1.62	1.69	1.77	1.84	1.91	1.98	2.05	2.12
120	1.39	1.46	1.53	1.60	1.67	1.74	1.81	1.87	1.94	2.01	2.08
122	1.37	1.43	1.50	1.57	1.64	1.71	1.78	1.84	1.91	1.98	2.04
124	1.34	1.41	1.48	1.55	1.61	1.68	1.75	1.81	1.88	1.95	2.01
126	1.32	1.39	1.46	1.52	1.59	1.65	1.72	1.79	1.85	1.92	1.98
128	1.30	1.37	1.43	1.50	1.56	1.63	1.69	1.76	1.82	1.89	1.95
130	1.28	1.35	1.41	1.47	1.54	1.60	1.67	1.73	1.79	1.86	1.92
134	1.24	1.31	1.37	1.43	1.49	1.55	1.62	1.68	1.74	1.80	1.87
136	1.23	1.29	1.35	1.41	1.47	1.53	1.59	1.65	1.72	1.78	1.84
140	1.19	1.25	1.31	1.37	1.43	1.49	1.55	1.61	1.67	1.73	1.79
144	1.16	1.22	1.27	1.33	1.39	1.45	1.50	1.56	1.62	1.68	1.74
146	1.14	1.20	1.26	1.31	1.37	1.43	1.48	1.54	1.60	1.66	1.71
150	1.11	1.17	1.22	1.28	1.33	1.39	1.44	1.50	1.56	1.61	1.67
154	1.08	1.14	1.19	1.24	1.30	1.35	1.41	1.46	1.52	1.57	1.62
156	1.07	1.12	1.18	1.23	1.28	1.34	1.39	1.44	1.50	1.55	1.60
160	1.04	1.09	1.15	1.20	1.25	1.30	1.35	1.41	1.46	1.51	1.56
164	1.02	1.07	1.12	1.17	1.22	1.27	1.32	1.37	1.42	1.47	1.52
166	1.00	1.05	1.10	1.15	1.20	1.26	1.31	1.35	1.41	1.46	1.51
170	.98	1.03	1.08	1.13	1.18	1.23	1.27	1.32	1.37	1.42	1.47
174	.96	1.01	1.05	1.10	1.15	1.20	1.25	1.29	1.34	1.39	1.44
176	.95	.99	1.04	1.09	1.14	1.18	1.23	1.28	1.33	1.37	1.42
180	.93	.97	1.02	1.06	1.11	1.16	1.20	1.25	1.30	1.34	1.39

(4)

YARDS OF CLOTH PER LOOM PER HOUR
(100% Production)

Picks per Inch.	155	160	165	170	175	180	185	190	195	200	205
	PICKS PER MINUTE										
90	2.87	2.96	3.06	3.15	3.24	3.33	3.43	3.52	3.61	3.70	3.80
92	2.81	2.90	2.99	3.08	3.17	3.26	3.35	3.44	3.53	3.62	3.71
94	2.75	2.84	2.93	3.01	3.10	3.19	3.28	3.37	3.46	3.55	3.63
96	2.69	2.78	2.86	2.95	3.04	3.13	3.21	3.30	3.39	3.47	3.56
98	2.64	2.72	2.81	2.89	2.98	3.06	3.15	3.23	3.32	3.40	3.49
100	2.58	2.67	2.75	2.83	2.92	3.00	3.08	3.17	3.25	3.33	3.44
102	2.53	2.61	2.70	2.78	2.86	2.94	3.02	3.10	3.19	3.27	3.35
104..	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.13	3.21	3.29
106	2.44	2.52	2.59	2.67	2.75	2.83	2.91	2.99	3.07	3.14	3.22
108	2.39	2.47	2.55	2.62	2.70	2.78	2.85	2.93	3.01	3.09	3.16
110	2.35	2.42	2.50	2.58	2.65	2.73	2.80	2.88	2.95	3.03	3.11
112	2.31	2.38	2.46	2.53	2.60	2.68	2.75	2.83	2.90	2.98	3.05
114	2.27	2.34	2.41	2.49	2.56	2.63	2.70	2.78	2.85	2.92	3.00
116	2.23	2.30	2.37	2.44	2.51	2.59	2.66	2.73	2.80	2.87	2.95
118	2.19	2.26	2.33	2.40	2.47	2.54	2.61	2.68	2.75	2.82	2.90
120	2.15	2.22	2.29	2.36	2.43	2.50	2.57	2.64	2.71	2.78	2.85
122	2.12	2.19	2.25	2.32	2.39	2.46	2.53	2.60	2.66	2.73	2.80
124	2.08	2.15	2.22	2.28	2.35	2.42	2.49	2.55	2.62	2.69	2.76
126	2.05	2.12	2.18	2.25	2.31	2.38	2.45	2.51	2.58	2.65	2.71
128	2.02	2.08	2.15	2.21	2.28	2.34	2.41	2.47	2.54	2.60	2.67
130	1.99	2.05	2.12	2.18	2.24	2.31	2.37	2.44	2.50	2.56	2.63
134	1.93	1.99	2.05	2.11	2.18	2.24	2.30	2.36	2.43	2.49	2.55
136	1.90	1.96	2.02	2.08	2.14	2.21	2.27	2.33	2.39	2.45	2.51
140	1.85	1.90	1.96	2.02	2.08	2.14	2.20	2.26	2.32	2.38	2.44
144	1.79	1.85	1.91	1.97	2.03	2.08	2.14	2.20	2.26	2.31	2.37
146	1.77	1.83	1.88	1.94	2.00	2.05	2.11	2.17	2.23	2.28	2.34
150	1.72	1.78	1.83	1.89	1.94	2.00	2.06	2.11	2.17	2.22	2.28
154	1.68	1.73	1.79	1.84	1.89	1.95	2.00	2.06	2.11	2.16	2.22
156	1.66	1.71	1.76	1.82	1.87	1.92	1.98	2.03	2.08	2.14	2.19
160	1.61	1.67	1.72	1.77	1.82	1.87	1.93	1.98	2.03	2.08	2.14
164	1.58	1.63	1.68	1.73	1.78	1.83	1.88	1.93	1.98	2.03	2.08
166	1.56	1.61	1.66	1.71	1.76	1.81	1.86	1.91	1.96	2.01	2.06
170	1.52	1.57	1.62	1.67	1.72	1.76	1.81	1.86	1.91	1.96	2.01
174	1.48	1.54	1.58	1.63	1.68	1.72	1.77	1.82	1.87	1.92	1.96
176	1.47	1.52	1.56	1.61	1.66	1.70	1.75	1.80	1.85	1.89	1.94
180	1.44	1.48	1.53	1.57	1.62	1.67	1.71	1.76	1.81	1.85	1.90

Warp and Filling Required from Spinning Room

The filling usually goes direct from the spindle to the shuttle and the only waste made is that at the loom itself. The warp undergoes several intermediate processes, such as spooling, warping, slashing, and drawing in, and more or less waste is made at each process in addition to waste at the loom. Some mills condition their filling yarns with the result that not only does the work run better but more pounds of filling are woven than are spun. In a large number of instances the sizing added at the slasher more than compensates for all warp waste between the spun yarn and the finished cloth. The weight of the cloth may therefore be more or it may be less than the weight of the yarns as spun for its manufacture. It is rare, however, that the percentages of warp yarn and of filling yarn in the woven cloth are exactly the same as the percentages of warp yarn and of filling yarn required from the spinning frame. In order to avoid an over or under supply of warp or of filling it is often of importance to know how to figure so as to ensure an exact balance between spinning and weaving.

To find warp and filling required to be spun to fill a certain cloth order:

RULE 62: *Ascertain weight of filling in cloth by Rule 35 and divide by 1 minus percentage filling waste to get weight of filling to be spun. Ascertain weight of unsized warp by Rule 36 and divide by 1 minus percentage warp waste to get weight of warp to be spun.*

EXAMPLE: A mill receives an order for 425,000

yards (100,000 pounds) of 39 inch, 72x76, 4.25-yard print cloth. Assuming 3% filling waste to be made at the loom and 5% warp waste to be made between the spun yarn and the woven cloth, how much warp and filling must be spun to fill this order?

ANSWER: As shown in the example given under Rules 35 and following, the woven cloth is composed of 53% warp yarn, 4% sizing, and 43% filling, therefore 100,000 pounds of the cloth is composed of 53,000 pounds of warp yarn and 43,000 pounds of filling yarn in addition to 4,000 pounds of sizing.

The warp required from the spinning frame will be 53,000 divided by 1 minus 5%, or .95, which is 55,790 pounds. The filling required from the spinning frame will be 43,000 divided by 1 minus 3%, or .97, which is 44,330 pounds. Therefore to make 100,000 pounds of cloth, containing 96,000 pounds of actual yarn, there is required 100,120 pounds of yarn from the spinning frames. In percentages we find:

Warp (sized) = 57% of cloth weight.
Warp (unsized- = 53% of cloth weight.
Warp (unsized) = 55.21% of actual yarn in cloth.
Warp (unsized) = 55.72% of actual yarn spun.
Filling = 43% of cloth weight.
Filling = 44.79% of actual yarn in cloth.
Filling = 44.28% of actual yarn spun.

LENGTH CLOTH THAT CAN BE WOVEN WITH A GIVEN AMOUNT OF WARP OR FILLING

To find length of cloth that can be woven from a warp of known weight and count:

RULE 63: *Multiply net weight of warp on loom beam by 1 minus percentage of sizing on warp, by warp count, by 840, by 1 minus warp contraction in weaving, and by 1 minus percentage of loss in weight of warp at loom; divide product by total ends in warp.*

EXAMPLE: A loom beam with 2700 ends of 30s is found to weigh 145 pounds net. It is known to carry 7½% sizing. How many yards of 39 inch, 68x72, 4.75-yard print cloth can be made therewith?

ANSWER: Sizing equals 7½%. 1 — 7½% = .925. From the table given for contraction in weaving plain cloths the warp contraction is found to be 8%. 1 — 8% = .92. The loss in weight of warp at loom, including sizing shaken or chafed off as well as warp yarn wasted at the beginning and ending of the weaving, may be estimated in this case at 1%. 1 — 1% = .99. Then the yards of cloth that can be woven from this warp =

$$\frac{145 \times .925 \times 30 \times 840 \times .92 \times .99}{2700} = 1140 \text{ yds.}$$

or 19 cuts of 60 yards each.

To find length of cloth that can be woven with a given weight and count of filling:

RULE 64: *Multiply weight of filling by count and by* 840, *also by* 1 *minus percentage of filling waste at loom; divide product by picks per inch and by width warp in reed.*

EXAMPLE: A 72-pick cloth that is spaced 42.1 inches wide in the reed is using 40s filling. There

are 55 pounds of filling on hand. Assuming a filling waste at the loom of 2%, what length of cloth can be woven therewith?

$$\text{ANSWER: } \frac{55 \times 40 \times 840 \times .98}{72 \times 42.1} = 597 \text{ yards.}$$

NOTE: This is a useful rule in ascertaining if the filling on hand is sufficient to complete an order calling for a certain number of yards. If it is not, then the additional amount of filling required for the remaining yardage can be ascertianed by the use of Rule 35, with due allowance for probable waste at loom.

LOOM SPEED CALCULATIONS.

Narrow looms are operated faster than wide looms, for instance a loom on 36-inch sheeting will ordinarily be speeded to put in fully twice as many picks per minute as a loom on 108-inch sheeting. This does not necessarily mean that the shuttle itself travels faster, for in fact in the instance cited the shuttle in the narrow loom will not cover as many feet per minute as the shuttle in the wider loom. The narrower the loom the larger the percentage of time lost in retardation of speed, bringing the shuttle to rest, at each end of its traverse. A normal shuttle speed is around 10 miles an hour, varying according to circumstances between 9 and 13 miles an hour.

The width, however, is only one of several factors that have to be considered in deciding upon the number of picks per minute most advisable and, even on the same cloth, looms of the same width will be found operated at different speeds in different mills. In general the slower the speed, within reasonable limits, the higher the percentage of the theoretical production obtainable and good judgment is required in deciding as to the picks per minute preferable. For instance, a mill may be weaving print cloth at 180 picks per minute and getting off 80 per cent production but find that by reducing the speed to 160 picks per minute it can get off 90 per cent production; the output per loom would be the same in either case but the change would probably be advisable because the slower speed would make easier work for the weaver and tend to fewer seconds.

English mills operate their looms faster than customary in this country. In most instances

this is due not so much to superior skill of the weaver as it is to the fewer looms given each weaver. As a rule the English weaver is required to do much extra work, such as bringing his own filling from the storeroom, unrolling and trimming and repairing cuts, carrying the perfected cloth to the warehouse, oiling, sweeping, etc., that in American mills is usually done by a cheaper class of operatives. This difference in methods, backed by the loom limitations laid down by the labor unions, accounts largely for the fact that the English weaver rarely operates over four looms (if he runs as many as six he always has a young "half-timer" assistant) on cloth that in the United States a weaver would tend 8 plain looms, or 12 if fitted with stop motions. The automatic looms, where the filling is automatically replenished, is used to a large extent in this country only; it is due to this that, in spite of higher wages made by the weaver, American weaving costs per yard are often less than those abroad.

Japanese looms are also operated faster than the American but this higher speed, together with the poor grade of material used (Japanese yarns are most largely of the coarse Indian cotton or a mixture thereof), and a lower degree of skill, means that only two or three looms can be given a weaver. In the United States, where wages are high, the main object is to obtain the maximum production from each operative; hence loom speeds are moderate and each weaver is given as many looms as he can handle. In low wage countries, such as Japan, the principal object is to get the maximum output from each machine; hence loom speeds are high and as many operatives are employed as are necessary to get the desired results.

The class of goods to be made and the type of loom to be used are prominent factors in the adjustment of the loom speed. The more complicated the design the slower the speed and dobbies are therefore run slower than ordinary cam looms, and Jacquards are run slower than dobbies. For some purposes cloth is required as near perfect as possible and in such cases the loom speed is reduced appreciably below that usual when operating on the same goods for ordinary uses.

The following table of loom speeds on medium weight cloth is taken from the catalogs of two prominent loom manufacturers, one making plain and one automatic looms.

Name of Loom or Cloth Width	Whitin Plain	Draper Automatic
28 inch	200 to 210	190 to 195
30 inch	195 to 200	185 to 190
32 inch	185 to 190	180 to 185
34 inch	180 to 185	175 to 180
36 inch	175 to 180	170 to 175
38 inch	170 to 175	165 to 170
40 inch	165 to 170	160 to 165
42 inch	160 to 165	154 to 158
44 inch	154 to 158	148 to 152
46 inch	150 to 154	144 to 148
48 inch	....	140 to 144
50 inch	142 to 148	....
52 inch	....	136 to 140
56 inch	138 to 140	132 to 136
60 inch	132 to 136	128 to 132
72 inch	116 to 120	116 to 120
80 inch	110 to 112	108 to 112
88 inch	104 to 106	100 to 104
92 inch	100 to 102	96 to 100

100 inch	94 to 96	90 to 94
108 inch	86 to 88	86 to 88
124 inch	75 to 80	....
150 inch	65 to 70	....

Although width is only one of several factors that decide speed, the foregoing is useful as an indication of the normal relation of speeds on looms of different widths.

In stating rules for loom speed calculations most writers disregard the fact that there is such a thing as belt slippage, with the result that there is not actually obtained the speed calculated. The percentage of speed lost by belt slippage varies according to conditions but, with proper care given the belts, will be around 3% for each belt and it is well to allow for this amount. If there are two belts between the main shaft and the loom and each slips 3%, a total of approximately 6% of the speed is thus lost. This means a loss of 8 to 12 picks per minute at the loom and belt slippage is therefore an appreciable item in most calculations dealing with the transmission of power by belting.

To find speed of loom, when speed of shafting, diameter of driving pulley, and diameter of loom pulley are known:

RULE 65: *Multiply speed of shafting by diameter of driving pulley, and by 1 minus percentage of belt slip; divide product by diameter of loom pulley.*

EXAMPLE: Shafting runs at 325 r. p. m. (revolutions per minute) and uses a 7-inch pulley driving down to a 14-inch pulley on loom. What is speed of loom if 3% is allowed for belt slippage?

ANSWER: $\dfrac{325 \times 7 \times .97}{14} = 157\frac{1}{2}$ picks per minute.

To find speed of shafting, when diameter of driving pulley, diameter of loom pulley, and speed of loom are known:

RULE 66: *Multiply speed of loom by diameter of loom pulley; divide product by diameter of driving pulley, and by 1 minus percentage of belt slip.*

EXAMPLE: With driving pulley of 7 inches diameter and loom pulley of 14 inches diameter, what would be speed of shafting required to give $157\frac{1}{2}$ picks per minute if belt slip be taken as 3%?

ANSWER: $\dfrac{157.5 \times 14}{7 \times .97} = 325$ r. p. m. of shafing

To find diameter of driving pulley, when speed of shafting, speed of loom, and diameter of loom pulleys are known:

RULE 67: *Multiply speed of loom by diameter of loom pulley; divide product by speed of shafting, and by 1 minus percentage of belt slip.*

EXAMPLE: Shafting runs 325 r. p. m., and loom has 14-inch pulley. If belt slip be taken as 3%, what is diameter of driving pulley required to give $157\frac{1}{2}$ picks per minute?

ANSWER: $\dfrac{157.5 \times 14}{325 \times .97} = 7$ inches diameter of driving pulley.

To find dameter of loom pulley, when speed

of loom, speed of shafting, and diameter of driving pulley are known:

RULE 68: *Multiply speed of shafting by diameter of driving pulley, and by 1 minus percentage of belt slip; divide product by speed of loom.*

EXAMPLE: Shafting runs at 325 r. p. m. and drives loom from a 7-inch pulley on shaft. Allowing for 3% belt slip, what is diameter of loom pulley required to give 157½ picks per minute?

ANSWER: $\dfrac{325 \times 7 \times .97}{157.5} = 14$ inches diameter of loom pulley.

To find diameter of loom pulley required in changing speed of loom, knowing diameter of loom pulley in use:

RULE 69: *Multiply present speed of loom by diameter of present loom pulley; divide results by loom speed desired.*

EXAMPLE: Loom is being run at 157½ picks per minute with 14-inch loom pulley; what loom pulley would be required to speed loom up to 165 picks per minute?

ANSWER: $\dfrac{157.5 \times 14}{165} = 13.36$ inches diameter loom pulley.

NOTE—Loom pulleys are normally made only in full inch diameters such as 10, 11, 12, 13, 14, 15, or 16 inches and where the above rule does not give an answer very close to the even inch it is necessary to change also some other pulley between the main shaft and the loom. Where a

countershaft is employed it is usually preferable to change the pulleys carrying the countershaft belt but any one or all of the four pulleys between the main shaft and the loom may be changed if circumstances warrant.

To find diameters of pulleys required to change speed of loom, knowing present speeds and diameters of pulleys being used:

RULE 70: *Divide speed of loom required by present speed of loom to ascertain percentage of change in speed required. Change one or more pulleys until product of driving pulleys divided by product of driven pulleys is changed to the extent of the percentage of change in loom speed desired.*

NOTE—The pulley on main shaft and every alternate pulley in the drive are driving pulleys; the pulley driven by main shaft and every alternate pulley are considered as driven pulleys.

EXAMPLE: Main line shafting runs at 300 r. p. m., using a 30-inch pulley to drive to a 27-inch pulley on countershaft. The countershaft has a 7-inch pulley driving down to a 14-inch pulley on loom. Present speed of loom is about 157 picks per minute. What changes should be made to obtain a loom speed of 165 picks per minute?

ANSWER: The proposed loom speed of 165, divided by the present loom speed of 157½ picks per minute, equals 1.0475, showing that the speed is to be increased by 4¾%. Present arrangement of pulleys is $\frac{30 \times 7}{27 \times 14}$. If it were possible to increase diameter of any one driving pulley by

$4\frac{3}{4}\%$, or decrease diameter of any driven pulley by $4\frac{3}{4}\%$, and get a pulley of commercial size, that would be the easiest arrangement. The change in diameter is, however, too small to make that practicable so it is necessary to try various combinations until we strike one where the product of the diameters of the driving pulleys divided by the product of the diameters of the driven pulleys is $4\frac{3}{4}\%$ more than that of the result of the present arrangement. In trying to make the change with two new pulleys only we may divide the main shaft pulley diameter (30 inches) times 1.0475 by the diameter of the countershaft receiving pulley (27 inches). This gives 1.162. Dividing a trial number 28 by a trial number 24 we get 1.166, which is very nearly the same, so we may use a 28-inch main shaft pulley and a 24-inch countershaft receiving pulley; in so doing we avoid changing either the countershaft driving pulley or the loom pulley.

PROOF:

$$\frac{300 \times 30 \times 7 \times .94}{27 \times 14} = 156.7 \text{ picks per minute present speed.}$$

$$\frac{300 \times 28 \times 7 \times .94}{24 \times 14} = 164.5 \text{ picks per minute required speed.}$$

To find difference in length of belt required when changing the size of one or both pulleys:

RULE 71: *Take the difference between the diameters of the pulleys, present and prospective, and one-half of the difference, and add to present belt length if the change is to pulleys the sum of whose diameters is larger than the sum of the*

diameters of the present pulleys, or subtract from present belt length if the sum of the diameters of the new pulleys is smaller than the sum of the diameters of the present pulleys.

EXAMPLE 1: A pulley of 14 inches is substituted for a loom pulley of 12 inches. What length should be added to the loom belt?

ANSWER: $14 - 12 = 2$. $2 \times 1\frac{1}{2} = 3$ inches longer belt required.

EXAMPLE 2: A countershaft belt runs on pulleys of 30 and 27 inches diameter, but these are replaced by 28 and 24 inch pulleys. Should the countershaft belt be lengthened or shortened and by how much?

ANSWER: 30 plus 27 equals 57; 28 plus 24 equals 52. The difference is $57 - 52$ or 5 inches. $1\frac{1}{2} \times 5 = 7\frac{1}{2}$ inches, which is the amount that needs to be cut out of the belt.

TYPICAL AMERICAN CLOTHS

TYPICAL AMERICAN CLOTHS.

A book on weave room calculations is hardly complete without some tabulation of cloths with their particulars. Such a list is of interest as illustrating the conditions that confront the weaver in various branches of the industry. The cotton weaving industry has many ramifications and a weaver on duck or coarse sheeting, for instance, usually has little opportunity to visualize the entirely different conditions that pertain to the weaving of organdies or venetians. It is not without suggestive value, at least, where a weaver has to make a cloth with which he is not familiar.

A full description of a cloth involves stating the weave, the width, the weight, the construction, and the yarn counts. This latter is usually omitted from such lists for the reason that, as previously shown, the same cloth may be made of many yarn combinations within a certain limit. That a blanket mill uses only 19s warp count, varying its filling from 3s to 6s to get the weights desired, does not mean that another mill may not be using 18s to 20s or other warp yarns and other counts of filling, but a statement of the yarns used in one mill, if typical, throws some light on the manufacture of blankets by showing that they are usually made of coarse yarns with the filling very much coarser than the warp. We have included typical yarn counts as indicative of the usual ranges and in order to make the tabulation completer and of more practical value.

The list does not attempt to be an exhaustive one but gives examples of cloths, many of them of large production, in some of the most important sections of the industry. The majority of the cotton cloths made in this country, in fact in the world, are plain-woven cloths using counts under

42s (the ordinary spinning limit of short-staple Upland cotton not over 1 1/16 inch in length) and it will be found that those shown are mainly of this predominating class.

In stating the counts of ply yarns, the count is shown first and the ply second, for instance 23/11 means 23s, 11-ply. In the wool industry the ply is usually given first and the count second, and this also obtains to some extent in the cotton industry, but we have followed the procedure that is most general and preferable. The figures 23/5/3 used in connection with the warp of cord tire fabrics indicates cabled yarn; five ends of 23s single are twisted together with wet, reverse twist, and then three ends of this ply yarn cabled with dry, regular twist.

	Width in inches.	Ounces per yard	Ends and picks per inch.	Warp yarn.	Filling yarn.
Number ducks:					
Sail duck No. 1	22	18	27x19½	7/5	7/6
Sail duck No. 2	22	17	27x20½	7/5	7/5
Sail duck No. 3	22	16	29x22	7/4	7/5
Sail duck No. 4	22	15	29x25	7/4	7/4
Sail duck No. 5	22	14	36x24	7/3	7/4
Sail duck No. 6	22	13	36x26	7/3	7/3
Sail duck No. 7	22	12	36x25	7/3	13/5
Sail duck No. 8	22	11	46x29	13/3	13/6
Sail duck No. 9	22	10	46x32	13/3	13/4
Sail duck No. 10	22	9	46x34	13/3	13/3
Sail duck No. 12	22	7	49½x30	12/2	12/3
Ounce ducks:					
Flat duck	29	8	88½x32	13s	9½/2
Flat duck	30	13	46½x35	13/3	12/3
Flat duck	36	12	35½x26	14/6	14/6
Flat tent-duck	29	8	76x30	9s	9s
Flat tent-duck	29½	8	78x27	8½s	7½s
Flat tent-duck	29½	10	78x27	7s	5.2s
Flat tent-duck	72	16	80x30	13s	16s
Army duck	28½	8	52½x42	14/2	15/2
Army duck	28½	10	47x38	14/3	14/2

Ounce ducks (continued):	Width in inches.	Ounces per yard.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Army duck	30¼	12.4	47¼x30	13/3	16/4
Army duck (for splitting)	60½	24.8	47¼x30	13/3	16/4
Harvester duck	44	20	40x33	13/4	12/3
Harvester duck	48	24	38x33	10/4	13/3
Bag duck	20	16	28x23	10/3	8/2
Shoe duck	37	8	50x36	14/2	23½/2
Enameling duck	38	8	83x24	13s	13/2
Enameling duck	46½	10.8	82x27	12¼s	14/2
Hose duck	40	8	26.6x20	10/2	10/2
Hose duck	40	10	28x21	13/3	7/2
Hose duck	40	12	30x21	12/3	7/2
Hose duck	40	14	28x19	8/3	8/3
Hose duck	40	16	26x16½	7/3	7/3
Hose duck	42	20	26x16	7/3	7/5
Belt duck	42	24	26x14	7/5	7/4
Belt duck	42	28	26x14½	7/5	7/6
Belt duck	42	30	25x15	7/6	8/6
Belt duck	42	30	26x15	7/5	7/7
Belt duck	42	32	24x13	7/7	7/6

	Width in inches.	Ounces per yard.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Tire fabrics:					
Building fabric ___________	48	23	23x23	23/11	23/11
Building fabric ___________	60	23¾	23x25	23/11	23/11
Building fabric ___________	60	30	24x24	23/11	23/11
Cord fabric ______________	60	23¼	26x2¾	23/5/3	20s
Cord fabric ______________	60	25	26½x2½	23/5/3	23s
Chafing fabric ____________	60	14	34x36	12/2	14/2
Chafing fabric ____________	60	15½	35x33	23/4	23/4
Breaker fabric ___________	60	20	12x13	23/12	23/12

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
		Grey Drills		
25	3.80	68x40	12.75s	16s
29	2.51	72x52	13.50s	10.60s
29	2.82	72x48	13.50s	13.30s
30	2.50	68x48	12.50s	11.75s
30	2.50	70x48	13.50s	10s
30	2.50	70x52	13s	12.50s
30	2.50	72x60	13.50s	14s
30	2.60	68x44	12.75s	11s
30	2.60	70x48	13.50s	10s
30	2.85	70x48	13s	15s
30	2.85	71x46	14s	14s
30	2.88	68x46	13s	13s
30	2.93	68x44	12.75s	15s
30	3.00	66x44	13.60s	14.25s
30	3.00	68x40	13s	13.50s
30	3.00	68x46	15s	15s
30	3.00	68x48	13s	14s
30	3.00	70x44	13s	15s
30	3.00	72x46	14s	14s
30	3.25	68x40	13s	17s
30	3.25	68x46	15s	15s
30	3.25	70x40	13s	18s
30	3.28	68x46	13s	18s
30	3.50	68x46	13s	20s
30	4.00	70x48	17.50s	20s
30¼	3.09	70x46	12s	16s
30½	2.45	70x50	13.50s	10.50s
31	3.05	68x40	12.50s	16.50s
32	2.69	70x46	13.50s	13.25s
36	2.28	68x56	13s	22s
37	2.35	68x40	15s	16s
37	2.35	70x48	15s	16s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
		Grey Drills (Continued)		
37	2.35	76x42	13s	14s
37	2.65	68x40	13s	17s
37	3.00	67x40	17s	20s
37	3.00	68x36	13s	22s
37	3.25	68x40	17s	17s
37	3.50	68x40	17s	20s
37	3.75	68x40	20s	20s
37	3.95	66x36	18s	23s
		Grey Jeans		
29	5.25	80x60	26.50s	33s
29½	3.53	96x64	22s	24.50s
30	4.00	88x56	21s	27s
30	5.00	96x64	28s	36s
32	3.31	96x64	22s	24.50s
39	2.75	96x64	22s	24.50s
39	2.89	96x64	28s	22s
39	3.00	96x64	22s	30s
39	3.10	96x64	22s	31s
		Wide Grey Drills		
40	2.03	70x48	13.50s	13s
40	2.40	68x40	13s	16s
40	3.06	63x40	22s	12s
40	3.96	68x40	24s	24s
46	1.75	76x42	13s	13s
46	2.00	70x42	13s	16s
51	1.81	70x42	13s	16.50s
52	1.90	68x40	13.50s	15.50s
58	1.60	68x40	13.50s	14s
59	1.85	68x40	13s	20s
59	1.94	68x40	17s	17s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
		Three-leaf Twills		
35	5.00	68x72	30s	36s
36	4.20	60x80	28s	28s
37	4.50	96x60	28s	40s
38½	3.10	96x64	28s	22s
39	3.65	80x92	28s	34s
39	3.75	80x84	28s	34s
39	3.90	80x80	28s	34s
39	4.00	68x76	28s	30s
39	4.25	68x76	28s	32s
39	4.50	68x76	28s	38s
39	4.80	64x72	30s	40s
39	5.10	64x64	28s	38s
39	5.25	64x56	28s	36s
39	6.00	64x48	30s	40s
39	6.60	56x44	28s	38s
40	2.94	66x64	26.50s	17s
43	3.25	80x92	28s	34s
43	3.50	80x84	28s	36s
43	3.55	68x76	28s	28s
43	4.00	68x68	28s	32s
43	4.00	68x76	30s	36s
43	4.00	80x76	28s	44s
43	4.30	68x60	28s	34s
43	4.50	68x76	30s	42s
43	4.75	68x52	28s	36s
		Four-leaf Twills		
30	2.00	88x48	12s	10s
30	2.10	88x58	12s	12s
30	2.12	80x42	11s	10s
30	2.15	88x48	12s	11s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Four-leaf Twills (Continued)				
30	2.31	88x48	13s	13s
30	2.40	88x48	13s	14s
30	2.50	88x38	12s	14s
30	2.65	88x38	13s	14s
30	2.85	88x38	15s	14s
30	3.00	86x40	18s	10s
30	3.00	88x38	15s	15s
30	3.25	88x38	17s	17s
30	3.50	88x38	17s	18s
31½	2.05	88x56	13s	13s
33½	1.73	86x62	13.50s	8s
37	1.75	86x44	12s	10s
37	1.95	76x42	12.50s	10s
37	2.00	88x42	13.50s	12s
37	2.10	86x44	13.50s	13s
37	2.35	76x42	13s	14s
59	1.76	76x44	18s	15s
Canton Flannels				
27¼	3.09	68x48	10s	8s
28	2.95	66x47	14s	9s
30	2.50	68x47	12¼s	10s
Corset Coutils				
38	1.70	104x80	17s	17s
38	1.85	124x84	24s	18s
38	2.15	86x68	22s	16s
38	2.15	104x80	22s	20s
38	2.25	96x80	22s	20s
38	2.53	112x56	22s	24.50s
38	2.73	108x56	28s	22s
38	3.05	100x56	28s	24s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Alberts (5-leaf lining twills)				
35	4.40	64x80	30s	32s
35	4.85	64x88	30s	43s
35	5.10	64x80	30s	43s
35	5.50	64x72	30s	45s
Warp Sateens				
27½	2.50	96x56	22s	8s
27½	3.70	112x64	22s	28s
29	4.20	112x64	28s	30s
30	2.85	88x38	14s	14s
30½	2.65	118x64	24s	15s
30½	3.00	118x64	22s	22s
30½	3.30	118x64	24s	22s
30½	3.35	112x64	22s	28s
30½	3.35	118x64	24s	22s
30½	3.50	112x64	26s	22s
30½	4.00	112x64	28s	30s
37	3.50	112x64	24s	45s
37½	3.65	112x64	28s	40s
40	3.00	112x64	28s	30s
42	3.50	112x64	28s	42s
42	3.50	140x84	42s	44s
42½	3.75	96x64	28s	40s
42½	3.90	96x60	28s	40s
42½	4.00	96x56	28s	40s
43	3.35	140x96	42s	44s
43	3.35	160x96	52s	44s
43	3.50	112x64	36s	32s
43	3.50	120x84	42s	36s
43	3.50	120x96	42s	44s
43	3.75	96x64	30s	40s
44	3.35	140x96	45s	50s
54	1.30	104x64	16s	16s

Width in inches.	Yards per lb.	Ends and picks per inch	Warp yarn.	Filling yarn.
Venetians				
35	2.85	156x64	30s	23s
35	3.15	156x64	30s	30s
35	3.18	156x64	30s	33s
38	2.63	156x64	30s	23s
38	2.90	156x64	30s	33s
35	3.00	156x64	60/2	30s
38	2.75	156x64	60/2	30s
Filling Sateens				
26½	6.85	64x72	28s	36s
28	5.85	64x68	28s	36s
31	4.00	72x120	28s	34s
31½	5.50	64x88	32s	37s
31½	5.50	64x124	34s	48s
33½	5.50	96x150	46s	66s
35	3.75	64x112	28s	36s
35	4.65	64x104	32s	38s
35	5.25	64x80	36s	32s
35	5.50	64x72	28s	40s
36	4.50	64x104	36s	34s
36	4.50	64x112	34s	41s
36	4.85	64x88	36s	34s
36½	4.00	100x132	45s	45s
37½	3.90	64x112	28s	36s
37½	4.00	64x104	32s	37s
37½	4.15	64x112	28s	42s
37½	4.25	64x96	28s	36s
37½	5.00	64x80	36s	33s
37½	5.25	64x72	28s	42s
39	3.75	64x112	28s	36s
39	3.75	84x124	32s	47s
39	3.75	96x132	36s	50s
39	3.75	96x132	40s	45s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.

Filling Sateens (Continued)

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
39	4.00	64x104	32s	37s
39	4.00	64x112	28s	42s
39	4.20	64x104	29s	43s
39	4.50	64x88	36s	34s
40	3.56	96x136	40s	45s
43	3.35	84x124	36s	40s
43	3.35	96x132	36s	48s
43	3.35	96x150	36s	54s
44	3.75	64x112	36s	38s
44	4.00	64x104	36s	38s

Grey Osnaburgs

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
28	2.28	30x30	5.50s	6s
29	2.90	30x32	8s	6.50s
29	3.33	30x30	8s	8s
29	3.33	32x30	8.50s	7.50s
29½	3.33	34x34	10s	8.50s
30	2.00	32x32	5.50s	6s
30	2.00	36x31	6s	5.50s
30	2.00	39x30	8.50s	4.75s
30	2.00	39x34	8.50s	5s
30	2.00	42x30	6s	6s
30	2.28	36x30	6s	7s
30	2.28	36x30	6s	7s
30	2.28	39x30	8.50s	5s
30	2.28	40x30	6s	6s
30	2.29	42x30	6s	8s
30	2.90	40x32	8.50s	7.75s
31	2.80	32x30	8.50s	6.20s
31½	2.00	30x30	5.50s	6s
35¼	3.33	37x28	11s	10s
36	2.30	32x24	8.50s	4.75s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Gray Osnaburgs (Continued)				
36	2.50	32x30	8.50s	6s
36	3.50	34x32	14s	9s
36	3.60	33x28	12s	10s
36	3.90	33x28	12s	13.50s
36	3.90	32x28	10s	9.50s
37	3.95	34x34	12s	12s
40	1.71	39x30	8.50s	4.75s
40	3.28	24x34	12s	10s
40	3.50	32x28	10s	9.50s
Osnaburg Tubing				
20	1.71	39x30	8.50s	4.75s
Coarse Sheetings (14s range)				
24	4.40	40x40	12s	12s
24	5.50	40x38	12s	16s
26½	5.00	40x38	12s	16s
27	4.70	44x42	13s	14s
28	4.00	48x48	12s	17.30s
30	3.60	48x48	14s	13.50s
30	3.75	48x48	12s	17.30s
31	3.50	48x44	14s	13s
33	3.40	48x48	12s	12s
36	2.85	40x40	11s	12s
36	2.85	48x48	12s	13.50s
36	2.99	48x48	13s	15s
36	3.00	48x44	14s	13s
36	3.00	48x46	13s	13.50s
36	3.00	48x48	14s	14s
36	3.25	40x40	12s	12.90s
36	3.25	48x40	13.50s	14.50s
36	3.25	48x44	13s	15s
36	3.25	48x48	13s	16s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Coarse Sheetings (14s range) (Continued)				
36	3.50	40x40	14s	11s
36	3.60	48x40	14s	16s
36	3.75	40x40	12s	16s
36	3.88	40x38	13s	13s
36	3.90	40x38	13s	16s
36½	3.50	44x40	13.50s	16s
39	2.60	48x48	13s	14s
40	2.35	48x46	11.50s	11.50s
40	2.50	48x46	11.50s	13.50s
40	2.50	48x48	13.50s	12s
40	2.66	48x48	13.50s	13.50s
40	2.70	48x48	14s	14s
40	2.85	48x44	13s	14.50s
40	2.85	48x48	14s	16s
Coarse Sheetings (18s range)				
26	6.25	44x44	20.50s	16s
30	4.50	48x48	17s	18s
30	5.00	48x44	18.50s	18.50s
30	5.00	44x48	16s	20s
31	4.50	44x44	17s	16s
31	4.70	44x44	17s	17s
31	4.99	46x46	18s	19.50s
31	5.00	48x48	21s	18s
36	3.20	65x64	18.50s	22s
36	4.00	48x48	18.50s	18.50s
36	4.00	48x52	17s	21s
36	4.00	52x48	19.50s	19s
36	4.50	44x36	20s	13s
36	4.50	48x44	20s	18s
37	4.00	48x48	17s	21s
37	4.00	48x48	20.50s	17s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Coarse Sheetings (18s range) (Continued)				
37	4.00	52x48	18s	22s
39½	2.40	64x64	16s	17s
40	2.92	65x64	18.50s	22s
40	3.60	48x48	18s	18s
40	3.75	44x40	17s	21s
40	3.75	48x44	20.50s	16s
40	4.25	44x40	17s	18s
Sheetings (22s range)				
30	5.50	48x48	21s	22s
32	4.50	56x60	21s	23s
32	6.25	40x40	21s	22s
34	5.82	48x40	21s	24s
34	6.00	40x40	21s	22s
34	6.50	40x40	21s	25s
36	3.25	68x72	22s	25s
36	3.25	68x76	21s	25s
36	3.50	64x68	22s	25s
36	3.60	64x68	21s	26s
36	3.68	64x62	20.50s	23s
36	3.70	64x68	22s	26s
36	3.75	60x64	21s	23s
36	4.00	56x60	21s	24s
36	4.00	60x56	21s	23s
36	4.00	60x60	21s	26s
36	4.20	56x56	23s	23s
36	4.25	56x56	22s	25s
36	4.50	48x52	21s	24s
36	4.50	56x52	22s	25s
36	4.50	60x48	21s	26s
36	4.69	52x48	20s	25s
36	4.70	48x50	21.50s	22s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Sheetings (22s range) (continued)				
36	4.70	48x52	20s	23s
36	4.70	52x48	20s	26s
36	5.00	44x44	21s	23s
36	5.00	48x48	21s	24s
36	5.20	46x46	21s	23s
36	5.50	44x44	21s	26s
36	5.50	48x40	21s	24s
36	5.50	48x44	21s	28s
36	6.00	40x40	21s	24s
36	6.15	40x36	20.50s	23s
37	5.50	44x44	21s	26s
38	4.00	48x52	21s	20s
38½	4.50	48x52	21s	28s
40	2.93	68x76	21s	25s
40	3.15	64x68	22s	25s
40	3.35	64x68	21s	28s
40	3.60	56x60	22s	25s
40	4.05	56x52	22s	25s
40	4.25	44x40	21s	24s
40	5.00	44x44	21s	26s
Sheetings (26s range)				
28	7.00	60x52	28s	27s
36	4.00	68x72	25s	29s
36	6.05	44x44	25s	27s
36	6.15	44x40	22s	28s
36	6.15	44x44	24s	26s
36	6.50	40x40	25s	27s
36	6.50	44x40	24s	26s
37	6.33	40x40	25s	27s
40	3.70	68x72	25s	29s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Wide Sheetings				
42	3.06	64x68	21s	25s
42	3.55	56x60	22s	25s
44	4.00	48x48	25s	27s
45	2.85	64x68	21s	25s
45	3.20	64x68	25s	25s
46	2.08	64x68	17s	18s
46	2.56	68x76	21s	25s
48	2.68	64x68	21s	25s
49½	2.36	68x76	21s	25s
50½	3.20	48x48	20s	21s
51½	3.85	48x48	24s	27s
51½	4.50	40x40	25s	27s
52	3.85	48x48	25s	27s
52	4.00	44x46	25s	27s
52	4.50	40x40	25s	28s
54	2.17	68x76	21s	25s
54	2.38	64x68	21s	25s
56	3.03	60x52	25s	27s
58	4.05	40x40	25s	27s
60	2.75	60x56	24s	26s
60	3.25	48x48	25s	27s
60	3.90	40x40	25s	27s
63	1.88	66x72	21s	26s
63	2.04	64x68	21s	25s
72	1.63	68x76	21s	25s
72	1.79	64x68	21s	25s
76	1.88	60x56	20s	22s
81	1.45	68x76	21s	25s
81	1.59	64x68	21s	25s
81	1.69	64x64	22s	25s
86	1.66	60x56	20s	22s
90	1.30	68x76	21s	25s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Wide Sheeting (Continued)				
90	1.32	66x72	21s	26s
90	1.43	64x68	21s	25s
99	1.30	64x68	21s	25s
108	1.01	66x72	21s	26s
108	1.25	56x56	20s	20s
118	1.00	64x64	20s	20s
126	.895	64x64	20s	20s
156	.76	64x64	20s	20s
Linoleum Fabrics				
22	10.00	40x40	20s	28s
27	9.00	44x44	30s	38s
30	6.66	48x48	24s	26s
51	3.85	48x48	24.50s	25s
51	4.55	56x56	30s	42s
51½	4.25	44x44	23.75s	27s
60	3.33	48x48	24s	26s
Narrow Cheese Cloths				
24	9.50	44x44	28s	29s
25	10.25	44x44	28s	31s
25	13.25	40x36	28s	38s
25	13.25	44x36	30s	39s
25	14.00	40x36	30s	40s
25	14.75	40x32	30s	40s
27	9.50	44x44	28s	31s
28	9.15	44x40	28s	29s
28	11.28	44x40	30s	40s
28	13.50	40x28	30s	37s
30	10.52	44x40	30s	40s
32	9.87	44x40	30s	40s
32	13.50	32x28	28s	42s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Narrow Cheese Cloths (Continued)				
32	14.50	34x22	28s	42s
34	9.40	44x40	29s	42s
Tobacco Cloths				
36	7.75	48x44	29s	38s
36	8.10	44x44	29s	38s
36	8.10	48x40	30s	36s
36	8.40	44x44	30s	39s
36	8.50	44x40	30s	37s
36	9.20	40x40	29s	40s
36	9.20	44x36	30s	39s
36	9.65	40x36	30s	38s
36	9.65	40x32	28s	37s
36	10.20	40x32	30s	38s
36	10.50	36x32	30s	37s
36	11.20	36x32	30s	41s
36	11.50	32x28	28s	36s
36	11.50	36x32	30s	43s
36	12.00	32x28	30s	37s
36	13.00	32x28	32s	41s
36	13.50	32x24	30s	41s
36	15.00	28x24	32s	41s
36	15.80	26x22	30s	41s
36	17.00	24x20	30s	40s
36	19.00	22x18	28s	42s
36	21.00	20x16	29s	42s
36	22.00	20x14	30s	40s
36	23.25	20x12	30s	39s
36	30.00	16x8	30s	37s
36	40.00	8x8	28s	31s
Wide Cheese Cloths				
37	9.38	40x36	30s	40s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Wide Cheese Cloths (Continued)				
38½	7.65	44x44	30s	39s
38½	8.00	44x40	30s	40s
38½	8.10	44x40	30s	40s
38½	8.20	40x40	28s	40s
38½	8.20	44x40	30s	40s
38½	8.50	44x36	29s	40s
39	8.00	44x40	30s	40s
39	9.20	40x32	30s	38s
39	9.80	40x28	28s	38s
40	9.10	40x32	30s	40s
40	10.80	32x28	30s	39s
42	7.00	33x44	28s	33s
42	7.50	44x40	30s	40s
42	10.50	32x28	30s	40s
43	8.25	40x32	28s	40s
44	7.25	44x40	29s	42s
44	8.50	36x32	28s	40s
Narrow Print Cloths				
24	10.77	56x44	29s	40s
25	7.60	64x60	28s	34s
25	8.21	64x60	30s	38s
25	10.55	56x44	30s	40s
25	11.00	52x44	29s	44s
26	7.06	64x72	30s	40s
27	6.00	72x76	28s	35s
27	7.46	64x60	30s	40s
27	7.60	64x60	30s	40s
27	7.85	64x56	29s	38s
27	8.70	56x56	30s	40s
27	8.70	56x60	30s	42s
27	8.77	56x52	30s	38s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Narrow Print Cloths (Continued)				
27	9.00	56x52	30s	40s
27	9.40	56x44	28s	38s
27	9.50	56x44	28s	38s
27	9.75	56x44	30s	40s
27	9.85	56x40	28s	38s
28	7.00	64x64	28s	40s
28	7.30	64x60	30s	40s
28	7.35	64x56	30s	40s
28	7.50	64x56	30s	40s
28	8.00	56x60	28s	40s
28	8.70	56x60	32s	43s
28	9.00	56x52	30s	41s
28	9.14	48x44	28s	34s
29	9.70	48x48	28s	42s
30	6.94	64x60	29.50s	42s
31	6.00	75x56	28s	36s
31	6.60	64x60	28s	38s
31½	5.36	64x88	30s	40s
31½	7.50	56x52	30s	38s
31½	7.54	56x52	30s	40s
31½	7.60	56x52	28s	42s
38½	8.45	56x40	30s	39s
32	5.75	64x60	28s	33s
32	6.12	64x64	30s	38s
32	6.20	64x60	30s	38s
32	6.50	64x60	29s	40s
32	8.50	48x48	30s	40s
32	8.80	48x48	28s	42s
34	5.00	68x72	28s	35s
34	6.00	64x60	30s	40s
34	8.00	48x48	30s	40s
35	5.00	68x72	30s	37s
35	6.70	56x44	29s	33s

Wide Print Cloths

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
36	5.00	64x64	28s	34s
36	5.50	64x64	30s	40s
36	6.00	56x56	30s	38s
36	6.43	60x52	29s	40s
36	7.00	52x52	28s	40s
38	5.20	64x56	28s	35s
38	6.75	56x44	30s	39s
38	7.15	48x48	30s	40s
38½	5.15	64x60	30s	38s
38½	5.15	64x64	30s	40s
38½	5.26	64x64	30s	40s
38½	5.35	64x60	30s	40s
38½	5.48	64x56	30s	38s
38½	5.50	64x52	30s	38s
38½	5.50	64x56	30s	40s
38½	5.54	64x64	30s	42s
38½	6.00	60x48	30s	38s
38½	6.00	60x52	30s	40s
38½	6.00	60x56	30s	41s
38½	6.25	60x48	30s	40s
38½	6.85	56x44	30s	40s
38½	7.01	48x48	30s	40s
38½	7.15	48x48	29s	40s
38½	7.30	52x40	29s	42s
39	4.00	80x80	30s	40s
39	4.25	68x76	29s	32s
39	4.25	72x76	30s	39s
39	4.50	68x76	29s	38s
39	4.50	68x80	30s	40s
39	4.66	68x72	28s	38s
39	4.67	68x72	30s	40s
39	4.75	68x72	30s	40s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.

Wide Print Cloths (Continued)

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
39	5.10	64x64	30s	40s
39	5.25	64x56	30s	40s
39	6.60	56x44	30s	40s
39½	6.00	56x56	30s	40s
39½	6.60	56x52	32s	42s
40	4.00	80x80	29s	39s
40	5.10	64x64	30s	40s
40	6.00	56x56	29s	44s
40	6.00	60x48	30s	40s
40	6.60	56x44	28s	44s
40	7.00	48x48	29s	42s
41	7.25	52x40	29s	44s
42	6.70	48x48	28s	43s
43	3.75	80x80	30s	42s
43	5.60	56x52	29s	38s
43	5.85	56x52	29s	38s
44	4.50	64x64	30s	40s
44	4.65	64x60	30s	40s
44	6.40	48x48	30s	41s
45	3.70	72x76	30s	38s

Gray Shirtings (Printcloth yarns)

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
34	5.10	94x80	42s	40s
38½	4.25	84x80	29s	46s
39	4.15	96x100	36s	44s
39	5.00	80x80	40s	46s
39½	3.60	76x92	30s	38s
39½	4.25	84x80	29s	46s
40	3.20	83x92	28s	33s
40	3.50	80x92	30s	38s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Longcloths (in the Grey)				
36½	5.15	96x104	40s	65s
39	4.65	100x116	50s	60s
39	4.95	96x104	50s	60s
39	5.00	80x80	34s	51s
39	5.00	80x88	30s	52s
39	5.00	96x100	50s	54s
39	5.25	96x92	50s	54s
39	5.50	96x100	50s	60s
39	6.00	72x68	40s	52s
39	6.00	80x76	40s	60s
39½	5.00	96x100	47s	58s
40	4.15	96x100	40s	50s
40	4.80	96x104	44s	62s
40	4.90	96x104	47s	57s
40	5.00	88x92	42s	62s
40	5.00	94x104	47s	58s
40	6.00	72x68	40s	50s
40	6.00	80x76	40s	65s
40	6.00	88x80	50s	60s
40	6.50	72x68	50s	54s
40	6.80	80x72	50s	60s
Nainsooks (in the Grey)				
28	10.50	82x78	54s	74s
28	10.73	80x80	50s	83s
28	11.00	84x87	50s	75s
30	9.60	85x80	54s	74s
30	10.04	83x76	55s	75s
32	8.41	92x100	60s	80s
33	7.70	88x92	55s	68s
33	8.00	84x88	55s	68s
33	8.30	80x84	55s	68s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Nainsooks (in the Grey) (Continued)				
33	8.35	96x96	60s	84s
33	8.50	76x80	55s	60s
33	8.75	84x80	55s	75s
33	9.55	76x80	55s	60s
35	7.00	116x124	60s	100s
35	7.30	116x116	60s	100s
35	7.70	108x116	60s	100s
35	8.00	108x104	60s	100s
35	8.70	100x100	60s	100s
Indiana Linons (in the Grey)				
28	12.00	60x60	50s	60s
29	12.15	68x68	50s	75s
30	12.30	64x64	50s	75s
30	13.00	72x68	60s	86s
30	12.50	72x72	60s	84s
30	12.00	76x72	60s	84s
30	11.75	76x76	60s	84s
30	11.16	76x84	60s	84s
30	12.00	80x76	60s	94s
30	11.25	80x80	60s	84s
30	11.50	80x80	60s	86s
30	11.04	84x80	60s	84s
30	11.35	88x80	60s	100s
30	11.10	88x84	60s	93s
30	11.00	88x88	60s	95s
30	10.75	88x92	60s	93s
30	10.75	92x88	60s	100s
30	10.40	92x92	60s	93s
30	10.23	92x96	60s	95s
30	10.06	92x100	60s	100s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Combed Lawns (in the Grey)				
40	9.50	72x68	60s	85s
40	9.00	76x72	60s	84s
40	9.00	80x80	60s	95s
40	9.00	80x80	60s	95s
40	10.50	84x80	70s	135s
40	10.55	84x80	80s	100s
40	8.50	88x80	60s	100s
40	10.50	88x80	80s	105s
40	7.50	96x92	60s	102s
40	9.40	96x92	80s	105s
40	7.00	96x100	60s	90s
Persian Lawns (in the Grey)				
30	16.46	80x80	90s	130s
30	12.75	96x100	80s	130s
30	11.75	104x110	80s	130s
30	14.00	108x120	110s	140s
32	15.58	76x64	90s	110s
32	15.36	76x68	80s	120s
32	15.15	80x76	100s	130s
32	17.31	80x80	100s	130s
32	15.95	84x80	100s	140s
32	16.42	88x84	100s	140s
32	16.70	88x88	100s	150s
32	16.38	88x96	110s	160s
32	16.44	92x92	110s	160s
32	15.64	96x96	110s	160s
32	14.88	100x92	120s	140s
32	14.52	104x100	120s	150s
32	13.97	104x108	120s	150s
32	14.49	104x112	120s	160s
32	14.12	108x116	120s	180s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Persian Lawns (in the Grey) (Continued)				
34	13.54	104x108	100s	150s
34	13.76	104x112	120s	160s
34	13.72	108x116	120s	180s
34	12.85	112x124	120s	180s
34	12.47	116x128	120s	180s
45	11.40	72x68	90s	120s
45	9.94	80x72	85s	115s
45	10.15	80x76	90s	120s
45	11.26	84x80	100s	140s
45	11.23	84x84	100s	140s
45	11.88	88x88	110s	150s
45	11.20	96x96	110s	160s
45	9.86	104x108	120s	150s
45	9.98	104x112	120s	160s
45	10.01	108x116	120s	180s
45	10.29	108x116	120s	180s
45	9.65	112x124	120s	180s
Voiles (in the Grey)				
40	8.22	60x56	50s	50s
40	9.86	60x56	60s	60s
27	9.00	34x34	35/2	45/2
27	8.32	49x46	60/2	60/2
40	8.00	62x56	100/2	100/2
40	9.80	64x64	140/2	140/2
Pajama Checks (in the Grey)				
36½	4.70	72x80	30s	41s
36½	5.20	66x72	28.50s	40s
36½	5.40	66x64	30s	42s
36½	5.75	64x60	30s	41s
37	4.00	88x80	30s	38s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Pajama Checks (in the Grey) (Continued)				
37	4.80	74x72	30s	42s
38	4.35	80x76	30s	42s
38	4.65	72x74	28.50s	41s
38½	4.60	72x74	28.50s	40s
Cotton Blankets				
46	2.74	41x32	19s	8s
50	2.35	43x24	19s	8s
54	2.06	42x28	19s	6s
60	1.30	40.1x30	19s	3s
60	1.41	41.6x29	19s	4s
60	1.88	39x30	19s	6s
64	1.41	40.7x28	19s	4s
64	1.61	40x30	19s	6s
64	1.69	40x28	19s	6s
66	1.18	39.4x30	19s	3s
70	1.48	39x32	19s	6s
72	1.10	40x30	19s	3s
Dimity quilts				
80	1.06	70x58	25s	11s
72	1.35	16x68	10s-25s	24s
Crochet quilts				
71x89	2.10	36x28	13/2	7s
72x84	2.61	30x28	9/2	13/3
72x88	3.17	36x28	9/2	9/2
78x90	3.72	37x35	15/3	15/3
Marseilles quilts				
80x90	3.14	66x84	20s-15s	14s-4¼s
76x86	3.66	63x88	25s-19s	11s-6s
76x88	4.51	92x112	30s-15s	26s-3s
80x89	5.05	105x145	25s-19s	32s-4s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
		Satin quilts		
76x88	3.00	60x48	25s-10s	24s-4s
76x88	3.50	60x54	25s-10s	24s-3½s
80x90	4.03	75x94	80/2-10s	45s-6s
80x90	4.39	90x120	80/2-30/2	65s-6s
		Denims and Coverts		
28	1.78	67x46	7s	11s
28	2.00	66x40	7s	11s
28	2.00	67x40	7.75s	10s
28	2.00	70x40	9.25s	9.50s
28	2.00	72x42	11.25s	12s
28	2.00	76x35	8s	9.50s
28	2.00	76x44	8.25s	12s
28	2.20	67x46	8s	14s
28	2.20	68x40	8.25s	14s
28	2.20	68x44	8s	15s
28	2.20	69x38	8.25s	14.50s
28	2.20	69x44	8s	16s
28	2.20	70x40	9.25s	11.50s
28	2.20	73x38	9.50s	10.50s
28	2.24	67½x26	12.50s	3.75s
28	2.40	62x38	8.75s	10.75s
28	2.40	64x38	9.70s	11.75s
28	2.40	66x40	9s	12s
28	2.40	68x42	9.25s	13.50s
28	2.40	69x42	9s	15.50s
28	2.40	70x38	9.25s	17.50s
28	2.40	70x40	9.70s	11s
28	2.40	75x44	10s	14s
28	2.45	68x42	9.25s	16s
28	2.45	70x40	9.25s	17.50s
28	2.45	72x38	10.50s	12s
28	2.45	74x41	10.50s	10s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Denims and Coverts (Continued)				
28	2.45	76x38	10.50s	12.50s
28	2.47	76x40	11s	10s
28	2.50	68x44	10s	15s
28	2.50	78x42	11s	10s
28	2.60	68x38	11.50s	10.75s
28	2.60	75x40	11s	15s
28	2.80	66x38	11.75s	12s
28	2.95	71x38	12.50s	13s
28	3.20	64x38	7.75s	10s
28	3.20	66x38	14s	12s
28¼	2.16	63x44	7.65s	14.56s
28¼	2.36	72x40	10.15s	11s
28¼	2.46	63x44	8.50s	16.25s
28¼	2.52	72x40	10.15s	14.75s
28¼	2.95	69x40	12.50s	13s
28½	1.60	68x48	7s	9s
28½	1.78	68x48	7s	11s
28½	1.99	63x44	7.30s	12.20s
28½	2.00	63x48	9s	13s
28½	2.15	63x44	7.65s	14.56s
28½	2.20	63x44	8s	15s
28½	2.39	66x40	8s	15s
28½	2.44	63x44	8.50s	16.25s
28½	2.50	67x44	9s	15.50s
28½	2.67	63x44	9.40s	17.93s
28½	2.80	65x44	9s	19.50s
28½	2.90	56x34	19s	5.40s
28½	2.98	63x38	10.50s	12.20s
28½	3.00	67x44	10.50s	19.50s
28½	3.25	68x40	10.50s	22s
28½	3.25	63x38	11.10s	20.60s
28½	3.49	63x38	11.80s	23.20s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Denims and Coverts (Continued)				
28½	3.50	58½x34	12.50s	13s
30	2.51	70x36	16s	16s
Tickings				
32	1.96	76x60	12s	12.50s
32	1.98	80x60	12.50s	12s
32	2.00	80x72	12.50s	14s
32	2.00	88x58	12s	16s
32	2.02	76x68	9s	14s
32	2.03	80x70	12s	16s
32	2.05	78x72	12.50s	16s
36	1.86	80x60	12.50s	14s
Straw Ticks				
30	3.75	73x40	14s	14s
30¼	2.53	65x52	10.50s	16s
31	2.61	76x54	14s	16s
31	2.94	71x46	12.50s	24s
Sateen Tickings				
32	2.13	100x52	12.50s	20s
32	3.25	100x44	18.50s	24s
33	2.00	100x72	12.50s	24s
51	1.28	100x52	12.50s	20s
64	1.06	100x52	12.50s	20s
Coarse Stripes				
26	3.00	58x38	10.50s	9.70s
27	3.20	71x50	12s	18.50s
27½	4.21	66x35	14s	16.25s
28	2.50	76x40	10.50s	12.50s
28	2.75	76x38	12s	12s
28	3.00	66x38	14s	14s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
		Coarse Stripse (Continued)		
28	3.10	74x48	12s	19.80s
28	3.50	60x40	13s	14s
28½	3.14	67x48	12s	17s
30	2.75	76x39	12s	14s
30	3.00	80x41	16s	12s
		Cheviots		
23	5.20	81x36	19s	16.30s
26	4.60	81x36	19s	16.30s
26½	3.00	58x38	9s	13s
26½	5.21	70x46	22s	25.35s
28	4.06	47x50	26s	10s
28	4.34	52x48	16s	16s
28	5.00	70x46	19s	23.75s
29	3.60	53x45	12s	14s
32	4.50	70x46	19s	25.35s
32	5.05	70x44	22s	25.35s
		Cottonades		
28	2.00	66x36	6s	10s
29	1.78	44x40	6s	6s
29	1.78	66x42	10s	6s
		Suitings, Napped		
28	2.88	70x40	12.50s	15.30s
		Suitings, All Cotton Worsteds		
28	2.24	42x34	12.50s	3.75s
		Suitings, Ply		
28	2.07	50x48	18.50/2	14/2

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Checks and Plaids				
25	5.00	44x38	14s	14s
25	6.00	38x34	14s	14s
26	4.90	46x36	17.50s	16.50s
27	3.95	52x36	16s	16s
27	4.50	44x44	14s	14s
27	4.57	46x39	14s	14s
27½	4.65	45x33	12s	14s
28	4.00	40x40	12s	13s
30	3.57	52x48	16s	16s
38	6.00	38x34	15s	15s
Flannelets, Outings, and Domets				
27	2.60	74x48	21.50s	6.50s
27	3.99	64x46	26.50s	9.75s
27	4.25	48x40	23s	12.50s
27	4.45	56x50	26s	12.50s
27	4.50	48x50	30s	11s
27	4.50	81x48	25s	15s
27	5.00	44x40	20s	12s
27	5.00	81x48	25s	19.50s
28	2.47	88x54	14s	11.20s
28	3.30	78x48	21.50s	9.75s
28	3.75	76x48	21.50s	12.50s
28	4.00	78x48	25s	12.50s
28	4.15	48x48	22s	11s
28	4.75	47x41	19s	12s
28	5.00	44x44	20s	14s
29	2.73	67x42	22s	8.10s
29	3.50	67x44	22s	9.75s
30	2.00	72x48	21.50s	5.50s
30	2.75	73x52	21.50s	7.80s
30	3.25	73x52	21.50s	11.75s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Flannelets, Outings and Domets (Continued)				
30	4.15	55x52	21.50s	14.50s
31	2.25	75x46	22s	5.95s
31	2.73	64x46	22s	8.25s
32	1.43	71x42	19s	3.50s
32	2.90	69x52	21.50s	9.75s
32	3.25	72x60	25s	13.50s
35½	2.18	64x44	17s	6.80s
36	1.50	40x36	19s	2.90s
36	2.00	56x40	19s	5.50s
36	2.20	48x44	13.60s	7s
36	2.50	41x44	21.50s	8.50s
36	3.00	59x48	21.50s	11.80s
36	3.50	63x48	21.50s	15s
36	3.85	54x48	25s	15.50s
39	3.50	48x42	26.50s	11.15s
40	2.01	64x46	22s	7s
40	2.30	48x44	13.60s	10s
40	3.06	63x40	22s	12.15s
40	4.02	42x44	26.50s	13.75s
40	5.60	24x24	26.50s	26.50s
42	2.16	46x44	22s	8.50s
42	4.50	45x38	22s	19s
42½	1.78	72x42	19s	5.90s
42½	2.25	49x42	22s	7s
44½	3.01	32x36	22s	8.75s
46	2.78	56x30	26.50s	7.45s
Cretonnes				
24½	6.45	64x49	28s	18s
27	3.85	62x51	17s	19s
27¾	7.14	60x52	28s	26s
28	7.00	62x62	31s	42s
30	2.56	111x55	19s	19s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
		Cretonnes (Continued)		
30	3.33	62x59	17s	19s
30	3.86	102x51	24s	30s
31½	3.06	62x62	16s	21s
33	2.82	111x51	24s	19s
35½	2.07	45x62	16s	9s
43	2.12	61x62	17s	17s
47¼	1.28	71x33	17s	5s
47¼	2.43	59x103	24s	29s
63	1.50	59x62	17s	17s
71	1.32	59x62	17s	17s
		Table Damask		
54	1.77	58x72	20s	17s
56	1.67	58x72	20s	17s
58	2.12	78x76	30s	22s
58	1.90	56x82	19s	20s
59	1.63	62x84	18s	16s
60	1.68	60x84	20s	20s
64	1.92	78x76	30s	22s
70	1.05	60x72	20s	20s
72	1.17	63x68	15s	16s
72	1.74	78x76	30s	22s
		Ginghams and Chambrays		
24½	7.15	64x68	22s	30s
26	6.23	68x48	22s	30s
26	6.40	76x64	31s	33s
26	7.90	62x54	26s	34s
26½	6.50	56x50	25s	25s
26½	6.50	68x52	25s	30s
26½	6.50	72x64	30s	40s
26½	6.74	76x52	32s	40s
26½	6.80	66x52	27s	40s

Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Ginghams and Chambrays (Continued)				
26½	7.00	70x54	28s	37s
26½	7.14	72x64	30s	40s
27	6.40	54x52	25s	25s
27	6.50	60x56	25s	35s
27	6.50	68x52	25s	30s
27	6.50	74x64	35s	35s
27	6.80	64x54	25s	35s
31½	5.25	68x50	22s	30s
32	5.05	70x44	22s	25½s
32	5.50	64x52	25s	35s
32	5.71	66x54	27s	40s
32	5.85	72x58	31s	33s
32	6.12	66x54	27s	40s
32	6.40	68x52	30s	36s
Fine Ginghams				
26	8.00	64x68	32s	50s
31	7.34	84x82	50s	56s
31¼	7.91	86x81	50s	50s
32	6.40	88x84	40s	50s
Fancy Ginghams.				
27	6.37	55x52	26s	26s
27	6.37	57x61	30s-16/2	28s-30s
27	6.70	72x52	45s-40/2	30/2-40/2
27½	6.58	76x49	40s-40/2	40/2-36/2

Miscellaneous Cloths

	Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Hickory shirting	27	3.12	88x56	14s	14s
Galatea cloth	30½	3.15	116x58	22s	20s
Drapery twill	26	6.03	60x52	28s	18s
Window Hollands	38	3.21	60x64	26.50s	17s
Window Hollands	76	1.58	60x60	18s	22s
Book cloth	42	3.71	48x56	24s	24s
Crepe kimono cloth	39	6.00	56x40	40s	20s
Crepe kimono cloth	40	5.12	53x40	31s	22s
Curtain scrim	36	5.41	24x24	20/2	24/2
Cotton serge	33½	3.22	53x50	28/2	28/2
Madras shirting	34½	5.15	105x90	50s	50s
Satin-striped shirting	34	5.10	94x80	42s	40s
Nainsook check	28	5.71	74x64	34s	24s
Dimity	26	11.10	76x48	42s	62s
Dimity	26½	10.20	83x56	42s	70s
Dimity	28	12.81	88x56	60s	70s
Dimity check	27	9.25	94x96	55s	70s
Dimity check	27	10.50	68x72	40s	60s
Dimity check	28	10.50	82x78	54s	74s

	Width in inches.	Yards per ℔.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Fancy dimity	27	12.00	94x72	100s-50s	120s
Lawn check	27	9.25	78x78	42s	70s
Lawn check	27	11.00	83x80	55s	75s
Lawn check	30	10.50	80x68	50s	80s
Lawn check	33	8.75	84x80	55s	75s
Embroidery cambric	53	4.25	82x72	40s	50s
Embroidery muslin	54	6.20	88x80	60s	100s
Typewriter cambric	39	5.06	143x154	90s	80s
Typewriter cambric	42	6.86	124x032	90s	100s
Soisette	34	6.75	68x100	80s	40s
Pongee	30	7.10	64x72	50s	30s
Pongee	34	6.75	72x100	70s	44s
Repp	50	1.31	88x31	32/2	5s
Poplin	27	9.70	103x46	80/2	36s
Poplin	28	5.27	101x48	60/2	25s
Bedford cord	29	4.10	124x86	26s	50s
Bedford cord	29	3.54	155x80	34s-24/2	40s
Pique	36	1.64	100x168	30s-30/2	30s-9s
Striped voile	29	8.60	68x44	68/2-43s	120/4
Marquisette	28	18.00	52x34	120/2	120/2

	Width in inches.	Yards per lb.	Ends and picks per inch.	Warp yarn.	Filling yarn.
Striped marquisette	30	12.15	74x32	40/2-55s	55s
Fancy leno	29	9.30	80x64	60s-70/2-28/3	85s
Dotted Swiss	28	9.89	68x70	60s	76s-12s
Dotted Swiss check	27	9.44	65x84	65s-16/2	84s-16s
Curtain Swiss or Madras	36	8.25	52x64	50s	60s-22s
Fancy or all-over Swiss	28	5.40	84x112	60s	90s-20s
Lappet-dotted Swiss	28	12.75	72x48	60s-18/2	62s
Cotton velvet	52	0.885	99x46	40/2-32/2	28/2
Velveteen	21	4.35	88x244	30s	40s-40s
Velveteen	25½	4.00	82x235	30s	40s-40s
Corduroy	25½	2.62	55x318	38/2	34s-34s
Jacquard tapestry	36	2.00	73x42	12.50s	9.75s
Jacquard tapestry	49½	0.795	151x90	30/2-78/2	40s-8s-6s
Jacquard tapestry	50	0.74	154x100	30/2-80/2	80/2-8s

TEXTILE MATERIALS & YARN NUMBERING

TEXTILE MATERIALS AND YARN NUMBERING

Textile fibers may be divided into vegetable fibers, animal fibers, and mineral fibers. A fourth division might be made of re-worked fibers.

Vegetable Fibers include cotton, jute, flax, hemp, ramie, manila, sisal, sunn, New Zealand flax, etc. Artificial silk and paper are not, strictly speaking, vegetable fibers but are made of vegetable substances and hence usually included in this class.

Animal Fibers include wool, silk, and hair; the main hairs used being mohair, alpaca, cashmere, and camel's hair.

Mineral Fibers include asbestos, finely spun glass, slag wool, and the metal threads used in tinsel and other yarns.

Re-Worked Fibers include wool noils, mungo, shoddy, extract, and flocks; also cotton waste.

The following table will be found of use as showing the systems used in numbering yarns of different materials and the method of obtaining equivalent counts in the cotton-yarn numbering system.

Yarn Numbering Systems and Equivalents

System	Yarn count is number of:	Cotton yarn equivalent:
Cotton	840-yard hanks in pound.	× 1.
Spun silk	840-yard hanks in pound.	× 1.
Thown silk	Drams to 1,000 yards.	304.76 ÷ drams.
Raw silk	Deniers to 450 meters.	5315 ÷ deniers.
Artificial silk	Deniers to 450 meters.	5315 ÷ deniers.
Worsted	560-yard hanks in pound.	× 2/3.
Woolen, run	1600-yard runs in pound.	× 1.905.
Woolen, cut	300-yard cuts in pound.	× .357.
Linen wet-spun	300-yard leas in pound.	× .357.
Flax dry-spun	Lbs. to 14,400-yard "spyndle".	17.14 ÷ lbs. per spyndle.
Jute	Lbs. to 14,400-yard "spyndle".	17.14 ÷ lbs. per spyndle.
Metric	1,000 meters per kilogram.	× 1.18.
French half-metric	1,000 meters per ½ kilogram.	× .59.

Mohair and alpaca are numbered the same as worsted, and hemp is numbered the same as wet-spun linen yarn.

In the leading textile industries—cotton, wool, and silk—there is an increasing trend towards the production of mixed goods, so that these industries are yearly becoming more interdependent. The cotton industry, for instance, has become a strong competitor of the silk industry, as cotton mills produce large amounts of cotton-back satins and dominate the trade in many lines of silk-and-cotton fancies. Cotton yarns are used in making mixed goods in practically every branch of the textile industry but the outside yarns of most interest to the cotton weaver are those of silk and artificial silk. After stating some facts in regard to raw cotton and cotton yarn, such as the cotton weaver should know, we will therefore close with a brief description of the processes involved in making silk and artificial silk yarns.

RAW COTTON

Cotton is the main textile fiber of the world and its mill consumption about equals that of all other textile fibers combined. It is a comparatively new fiber, as compared with wool or flax, and the modern cotton-manufacturing industry may be said to date from the invention of the cotton gin by Elias Whitney in 1793. The world's total crop averages around 22,000,000 bales, of 500 pounds each, and the demand is increasing faster than the supply, particularly in regard to "staple" cottons. The United States produces about 60% of the total and is followed by India. China, Egypt, Russia, and Brazil are the only other cotton-producing countries of importance.

The United States is the largest consumer of cotton and in 1919 was followed by the United Kingdom, Japan, India, and China. In normal times Germany, Russia, France, Austria, and Italy are also large consumers.

The cottons of interest to the American spinner and weaver may be enumerated as follows:

Short-staple Uplands. This type constitutes the bulk of the American crop and consists of cotton between 7/8 and 1 1/16 inches in length. It is used only for coarse and medium counts, rarely for ringspun yarns much above 40s, but the bulk of the cotton goods of the world are made of yarns under this number. Using mules, the English spin short-staple Uplands to 50s or slightly above. Texas, Georgia, South Carolina, Mississippi, Arkansas, and North Carolina are the leading producers.

Long-staple Uplands. American "staple" cotton of 1⅛ to 1⅜ inches (a trifle of "extra" or

"fancy" staple attaining lengths up to 1⅝ inches) is of the same species as the short-staple type though it is possible that some of the longest have been slightly crossed with Sea Island. The cultivation of these long-staple varieties (known as Peelers, Benders, Allanseed, etc.) is mainly confined to the Mississippi delta and the lowlands of Louisiana.

Sea Islands. The longest, finest, silkiest, and most costly of all cottons is grown on islands off the coast of South Carolina but the total amounts to only a few thousand bales. Some of this cotton exceeds 2 inches in length. Georgia and Florida produce larger amounts of commercial Sea Island, but of an inferior type, the staple ranging from 1⅜ inches upward. The total Sea Island crop rarely exceeds 100,000 bales and is now much less.

American-Egyptians. In recent years efforts have been made to grow Egyptian cotton in the United States and these have met with success in lower California and Arizona. The crop now amounts to about 50,000 bales and is increasing. By careful seed selection the staple has been improved until it averages a full 1⅝ inches. This cotton is most largely used for tire fabrics.

Egyptians. There are several varieties of Egyptian cotton. Formerly the brown-tinged Mitafifi was the main type but this has been superseded by the longer and whiter Sakelaridis (often called Sakel). Egypt is the main producer of long-staple cotton although its total crop is rarely over 1,500,000 bales (of equivalent 500 lbs.) The United Kingdom is the largest consumer of Egyptian cotton and exceeds all other countries in the

production of fine counts. American imports of Egyptian cotton are mainly for use in coarse yarns for tire fabrics.

Indian and Chinese Cottons. These cottons are mainly harsh and of short staple. There is a small import for use in blankets and cheap colored cottons.

Starting with one-inch cotton as suitable for 20s warp, we can figure that every sixteenth of an inch addition to the length of the staple increases the spinning range by about ten counts. The following may be taken as indicative of the normal practice in the United States.

Normal Usage of Raw Cottons by American Spinners

Cotton Staple, Inches.	Will Spin to Following Warp Counts.	Filling Counts.	Type of Cotton.
¾ to 15/16	10s	15s	Low-grade Uplands.
1	20s	30s	Uplands.
1 1/16	30s	40s	Uplands.
1⅛	40s	50s	Rivers, Creeks.
1 3/16	50s	60s	Benders.
1¼	60s	70s	Peelers, Mitafifi.
1 5/16	70s	80s	Peelers, Mitafifi.
1⅜	80s	90s	Peelers, Mitafifi, low Sea Islands.
1 7/16	90s	100s	Allanseed, Mitafifi, low Sea Islands.
1½	100s	120s	Allenseed, Sakel, Sea Island.
1⅝	120s	150s	Sakel, Sea Island.
1¾	140s	180s	Sakel, Sea Island.
2	200s	250s	Selected Sea Island.
2¼	250s	300s	Best Sea Island.

The above is given only as an indication for the spinning limit of cotton depends, not alone on the staple, but also on the grade and the type of cotton. The same cotton can be spun to finer counts on the mule than on the ring frame; and the staple and grade of cotton used has to be varied according to the perfection of yarn desired.

COTTON YARN

Cotton yarn is numbered according to the number of 840-yard hanks that weigh one pound. Thus No. 10 measures 8,400 yards to the pound and No. 100 measures 84,000 yards to the pound. It is claimed that cotton has been spun to No. 2000; this would measure 1,680,000 yards or 318 miles to the pound. Commercially cotton is rarely spun to over No. 300, and No. 260, used in the lace industry, is the finest yarn imported. A few American mills spin up to 200s for their own use but normally there is little made here above 100s warp or 120s filling.

Table of Lengths for Cotton Yarns

Cotton Counts	Yards per Pound	Cotton Counts	Yards per Pound	Cotton Counts	Yards per Pound
½	420	35	29,400	79	66,360
1	840	36	30,240	80	67,200
1½	1,260	37	31,080	82	68.880
2	1,680	38	31,920	84	70,560
2½	2,100	39	32,760	86	72,240
3	2,520	40	33,360	88	73,920
3½	2,940	41	34,440	90	75,600
4	3,360	42	35,280	92	77,280
4½	3,780	43	36,120	94	78,960
5	4,200	44	36,960	96	80,640
5½	4,620	45	37,800	98	82,320
6	5,040	46	38,640	100	84,000
6½	5,460	47	39,480	105	88,200
7	5,880	48	40,320	110	92,400
7½	6,300	49	41,160	115	96,600
8	6,720	50	42,000	120	100,800
8½	7,140	51	42,840	125	105,000
9	7,560	52	43,680	130	109,200
9½	7,980	53	44,520	135	113,400
10	8,400	54	45,360	140	117,600
11	9,240	55	46,200	145	121,800
12	10,080	56	47,040	150	126,000
13	10,920	57	47,880	155	130,200
14	11,760	58	48,720	160	134,400
15	12,600	59	49,560	165	138,600
16	13,440	60	50,400	170	142,800
17	14,280	61	51,240	175	147,000
18	15,120	62	52,080	180	151,200
19	15,960	63	52,920	185	155,400
20	16,800	64	53,760	190	159,600
21	17,640	65	54,600	195	163,800
22	18,480	66	55,440	200	168,000
23	19,320	67	56,280	205	172,200
24	20,160	68	57,120	210	176,400
25	21,000	69	57,960	215	180,600
26	21,840	70	58,800	220	184,800
27	22,680	71	59,640	225	189,000
28	23,520	72	60,480	230	193,200
29	24,360	73	61,320	235	197,400
30	25,200	74	62,160	240	201,600
31	26,040	75	63,000	245	205,800
32	26,880	76	63,840	250	210,000
33	27,720	77	64,680	255	214,200
34	28,560	78	65,520	260	218,400

Cotton yarn may be either carded or combed. Some yarns are double carded, at a cost about intermediate between ordinary carded and ordinary combed. Extreme fine counts, such as 250s, are double combed. Ordinarily the finer the yarn the higher the percentage of waste. In the manufacture of coarse carded yarns for osnaburgs or the lower grades of duck the waste may be under 12%; for sheetings it is ordinarily about 15% and for print cloths about 18%. Ordinary combed yarns average around 30% waste. In the case of double-combed yarns the waste may be as much as 40%. These percentages are based on the gross weight of the raw cotton, and in figuring costs they are reduced by reason of the return from waste sold. In making sheeting yarns, for instance the waste is usually about 15% of the quantity, but only 12% of the value, of the cotton used.

American yarns are usually ring spun and ring twisted. English yarns are usually mule spun and ring twisted, but where ply yarns of superior quality are required for fine lace work there is used a flyer twister. The flyer twister with its slower and more positive speed is essential for perfection in twisting.

Yarns may be unbleached, bleached, dyed, printed, or colored. The term "colored" includes ply yarns made of a gray and a colored yarn. Single yarns spun with one gray and one dyed roving are known as "mock twist" yarns and are largely used as filling in denims.

Unprocessed yarns are known as "plain" yarns in contradistinction to yarns finished by gassing, mercerizing, polishing, or other process.

In gassing, the yarn is passed one or more times through the blue part of the flame from a Bunsen

gas burner, the speed being regulated so that the fuzz of projecting fibers which is found on all plain yarns is burned off without the yarn itself catching fire. Gassed yarn shows up smoother, rounder, and brighter though slightly darker in shade. An incidental but important result is that the yarn, by reason of the removal of the fuzz, weighs less per yard and is therefore raised to a higher count; to make 100/2 for instance it is necessary to spin to only about 94s. Owing to the danger of tendering, cotton yarns are rarely gassed in the single.

In mercerizing, the yarn is subjected to the action of an alkali such as caustic soda and kept under tension during the process. The object of mercerization is to obtain a lustrous silk-like finish; incidentally the yarn is increased in strength and in affinity for dyestuffs. The caustic soda appears to be absorbed by the cotton fiber which swells and thereby straightens out from its normal twisted-ribbon form; if the tendency to contract in length is prevented, the fiber assumes an appearance more cylindrical and hairlike, and the smoother and more cylindrical shape makes it a better light reflector and therefore more lustrous.

Not only sewing thread but large amounts of cotton yarn are finished by polishing and used in making shoe laces, braids, "luster linings," and upholstery fabrics (including imitation haircloth).

About three-fourths of the yarns spun in the United States are used in the mills where spun. The knitting industry is the largest outlet for those spun for the market. Cotton yarns are also bought for use in the lace, lace-curtain, embroidery, and braid industries; and for weaving mixed

goods in silk, mohair, or wool mills; in addition to those required by cotton weaving mills which, either because they are not equipped with spindles or because they require special counts or qualities, buy outside. Imports of cotton yarn are negligible and consist mainly of fine two-ply yarns mulespun of Egyptian cotton.

SILK

Silk is the product of the silk worm or caterpillar. The domesticated worm is fed on mulberry leaves stripped from the trees. After feeding for about a month the worm spins its cocoon or silken envelope; the silk fluid is exuded from the worm's underlip in two strands, called "brins," which immediately unite to form the "bave" or silk filament. After completely enveloping itself the worm turns to a chrysalis and this in turn, if not killed, becomes a moth which breaks its way out of one end of the cocoon. The female moth lays her eggs and dies shortly thereafter. The cycle from birth to death, including all transformations, is less than 60 days, and the eggs are kept in cold storage until time for the next crop. Pierced cocoons, from which the moths have emerged, cannot be reeled because of the broken filaments, so only about 2 per cent of the chrysalides are allowed to develop into moths, the remainder are killed in the cocoon, usually by stifling in hot, dry air.

Tussah silks, used in the production of goods of rough appearance, are produced by wild (i. e. undomesticated) silk worms that feed on the leaves of the oak and other trees.

The main silk-producing countries are Japan, China, and Italy. The United States is the largest manufacturer of silk but imports all of its

raw material. Although produced by cheap labor, silk is the most costly of all fibers because of the great amount of time and care involved in raising the worm and reeling the silk. Because of the economic difficulty, all efforts to raise silk in the United States have proved failures.

There are two general classes of silk: (1) Raw, or reeled, silk, from which is made thrown-silk yarn; and (2) Waste silk, from which is made spun-silk yarn.

Raw Silk

Raw Silk is a term used specifically to denote silk in skeins, as reeled from the cocoon or re-reeled. Its meaning is therefore more circumscribed than that of such terms as raw cotton or raw wool since a large proportion of the silk supply of the world, known as silk waste, is unreelable.

Raw silk is the finest, most elastic, and most durable of all textile fibers. It is specially prized for its brilliant luster.

Reeling is a simple but tedious process, as it requires the product of from 2,500 to 3,000 silkworms to produce a pound of raw silk.

Raw silks are known according to place of origin as Kansai, Shinshiu, Canton, Shanghai, etc., and classified into Special Grand Extra, Extra Extra A, Extra Extra B, Best Extra, Extra, Best No. 1, etc. The system of classification is very unsatisfactory as the "best extra" of one chop (reeler's trademark) may not be as good as the "extra" of another chop, and the classifications by various reelers vary in quality from season to season.

Raw silk is numbered according to the weight in deniers of a skein 450 meters in length. A de-

nier is 5 centigrams, equivalent to 0.771618 grain, and 450 meters is equivalent to 492.125 yards; therefore the constant 4,464,528 divided by the denierage will give the yards per pound. As this system is based on the weight of an arbitrary fixed length, the finer the silk the smaller is the count; this is the reverse of the system used in numbering yarns of cotton or wool.

The silk filament, as spun by the worm, is too attenuated to stand much strain, so in reeling the filaments from 3 to 12 cocoons are united to form the raw-silk thread of commerce. The 13/15 denier silk, generally reeled from 5 or 6 cocoons, is usually taken as the standard count, and is the raw silk in largest demand for throwing and dyeing. Owing to the variation in size of different cocoon filaments, and of the same filament at different portions of its length, it is impossible to make the combined raw-silk thread of an exact size; in specifying the number, therefore, the limits are usually given 2 denier apart. 13/15 denier raw silk means that 450 meters weighs between 13 and 15 denier, the average is 14 and if the constant 4,464,528 be divided by 14 we get 318,895 as equivalent yards per pound, equal to No. 380 cotton yarn. Usual sizes of raw silk are 8/10 to 28/30 deniers (say within the extreme limits of 558,066 to 148,818 yards to the pound, equivalent to cotton counts of No. 664 to No. 177); the production of sizes finer or coarser is very limited.

Some silk goods are woven of raw silk in the gum; these fabrics, after boiling out of the gum and bleaching, have a softness and brilliancy unattainable in cloths made of thrown-silk yarns. The famous "habutae" of Japan is a striking illustration of such work, but at least a fourth of

American raw silk imports is woven in the gum, without any throwing.

Thrown Silk

Thrown Silk may be defined as yarn made from raw silk, that is, from silk reeled from the cocoon. Raw silk consists of several parallel cocoon filaments held together by the natural gum only. The proportion of gum varies but a pound (16 ounces) of raw silk usually contains 3 to 4 ounces of gum. Silk cannot be boiled off, dyed and weighted, and remain in workable condition. If the silk is to be skein dyed it must therefore first be thrown into yarn.

Silk "throwing" (from the Saxon "thrawan", to twist) is the technical term used for the processes involved in making yarn from raw silk. As raw silk is already in the form of a continuous strand, the only processes involved are soaking (to soften the gum), winding, doubling, spinning (without drafting), and reeling. Raw silk is the single and thrown silk is the ply yarn. Cotton yarns, doubled, are known as 2-ply warp, 3-ply filling, etc., whereas thrown silk yarns are similarly designated as 2-thread organzine, 3-thread tram, etc.

Organzine (often called "organ"), used for warp, is made by doubling two or more threads which have first been well twisted in the single, and then giving them a firm twisting in the opposite direction.

Tram, used for filling, is made by combining two or more threads and then twisting them together with a slack twist. Strength is not as essential as it is in the warp, and the slack twisted filling permits a more brilliant finish.

In the United States, as in England, thrown silk is usually numbered according to the weight in drams of 1,000 yards. As there are 16 drams to the ounce and 16 ounces to the pound, this is equivalent to the weight in pounds of 256,000 yards. In Continental Europe thrown silk is numbered the same as raw silk.

To reduce denier counts to dram counts, divide the deniers by 17.44. Thus 2-thread organ of 13/15 deniers would be $14 \times 2 = 28 \div 17.44 =$ 1.60 drams; and 4-thread tram of 16/18 deniers would be $17 \times 4 = 68 \div 17.44 = 3.90$ drams. Organzine is usually between 1.50 and 2.50 drams, and tram between 1.70 and 5.10 drams. For the hosiery industry silk is thrown into yarn as coarse as 10 drams.

The standard tram twist is about 5 turns to the inch; the standard organzine twist is stated as 14/16 turns to the inch, meaning 14 turns in the singles and 16 turns in the ply. Crepe yarns are much harder twisted. Some Georgette crepe yarns contain as high as 100 turns per inch. The cost of throwing Georgette crepe yarn is more than double the cost of throwing organzine, and about four times the cost of throwing tram.

Silk Waste

Silk Waste is a term used to include all silk other than that reeled from the cocoon. It is only to a small extent the by-product of manufacture and the majority is silk that has never been used but which, from one cause or another, was found unreelable.

Only about half of the silk in a good cocoon is reelable, as the outer layers are usually coarse, uneven, and broken, while the extreme inner lay-

ers, spun as the worm is nearing exhaustion of its supply, are too attenuated to stand the strain of reeling. Many wild silks are either unreelable or more profitably worked as waste. Cocoons from which the moths have emerged, necessarily breaking the filaments in their exit, are known as "pierced cocoons," and classed among the best of "waste silks." Of the silk wastes that are the by-product of manufacture the most important are the exhausted noils from the last dressing or combing process.

Silk waste is imported from China, Japan, and Italy.

Spun Silk

Spun Silk is made from silk waste. The waste is first degummed, opened up and lapped, and then combed on a series of three or more "dressing machines." The first "drafts" or combed lengths from the dressing machines are prepared, on machines similar to those used in the preliminary manufacture of flax and other long fibers, and then spun into yarn. The noil or shorter fibers discarded in combing are carded and spun into yarn on machines very similar to those used in the cotton industry.

The consumption of spun silk is steadily growing, since such yarns are cheaper than thrown silk and for many purposes fully as acceptable. Spun silk finds its main use as pile yarn in the manufacture of silk velvets (usually made with a cotton back), but is employed in many other lines, particularly in tissues to be piece-dyed or printed. Large amounts are used in cotton and wool mills in the production of mixed goods.

There are two general systems for numbering

spun silk. In the metric system, used on the Continent, the count indicates the number of thousand meters per kilogram, and is based on the singles. In the English system, which is more generally employed in this country, the count indicates the number of 840-yard hanks to the pound. The latter is similar to cotton-yarn numbering so far as single yarn is concerned, but is different for ply yarn, where cotton is based on the single and spun silk on the finished yarn. For instance 100/1 cotton or spun silk yarn measures 84,000 yards to the pound; 100/2 cotton yarn, however, consists of two ends of 100s and measures only 42,000 yards to the pound whereas 100/2 spun silk consists of two ends of 200s and so measures 84,000 yards to the pound.

ARTIFICIAL SILK

There are three principal types of artificial silk. The type mainly produced in the United States and England is known as viscose silk, or woodsilk, and is made from woodpulp. Nitro-cellulose silks and cupra-ammonium silks are produced mainly in Belgium, France, and Germany, and are made from cotton waste or linters.

The general principle of the apparatus used in "spinning" artificial silk is simple, but there are many different designs which are continually being improved upon. The woodpulp or cotton waste, after being chemically treated and reduced to a pasty mass of the required consistency, is introduced into the spinning apparatus, a stout reservoir, and is then forced therefrom, by continuous air pressure, through a series of tubes terminating in glass or platinum nozzles with capillary openings varying, according to the size of the fila-

ments desired, from one three-hundreds to one fiftieth of an inch. As the individual filaments, usually 5 to 8 deniers in size, are too fine for commercial use, 12 to 32 filaments are always combined to form the "single" of artificial silk yarn.

Artificial silk is numbered according to the raw silk system, by the weight in deniers (0.05 gram) of a standard length of 450 meters. The constant 5,315 divided by the denierage gives the equivalent cotton counts. The domestic viscose silk is made mainly into 150 and 300 deniers, equivalent to No. 35.4 and No. 17.7 cotton counts. Some nitro-cellulose Chardonnet silks are imported as fine as 60 deniers, equivalent to No. 88.6 cotton count.

Artificial silks are more lustrous than real silk but are heavier, weaker, less elastic, and more difficult to manipulate. The price per pound is less than that of natural silk, though this is to a small extent offset by the fact that the specific gravity of artificial silk is about 10 to 20 per cent greater. One of the chief drawbacks to its use in cloths has been its inability to withstand moisture, but some varieties, even of woodsilk, have now been perfected to the extent that they can be used in wash goods. The demand for artificial silk is steadily increasing and there is apparently no limit to its possibilities. It is not impossible that in time the producton of artificial silk may surpass that of natural slk.

ARTIFICIAL HORSEHAIR

Artificial horsehair differs from artificial silk in that it is coarser and stiffer. It also differs in the fact that it is produced and used in coarse single filaments and not, as in the case of artificial silk in fine filaments which must be combined before use. Artificial horsehair comes only in very coarse sizes, mainly the 300 and 600 deniers, equivalent to No. 17.7 and No. 8.9 cotton counts.

APPENDIX

U. S. WEIGHTS AND MEASURES

Linear Measures

12	inches (in.)	= 1 foot (ft.)
3	feet	= 1 yard (yd.)
1,760	yards	= 1 mile.

Square Measures

144	square inches (sq. in)	= 1 square foot (sq. ft.)
9	square feet	= 1 square yard (sq. yd.)
4,840	square yards	= 1 acre.
3,097,600	square yards	= 1 square mile.

Cubic Measures

1,728	cubic inches (cu. in.)	= 1 cubic foot (cu. ft.)
27	cubic feet	= 1 cubic yard.

Weight Measures

16	drams (dr.)	= 1 ounce (oz.)
16	ounces	= 1 pound.
437½	grains	= 1 ounce.
7,000	grains	= 1 pound.
2,000	pounds	= 1 ton.
2,240	pounds	= 1 long ton.

Liquid Measures

2	pints (pt.)	= 1 quart (qt.)
4	quarts	= 1 gallon (gal.)
31½	gallons	= 1 barrel (bbl.)

(A gallon contains 231 cubic inches.)

Dry Measures

2	pints (pt.)	= 1 quart (qt.)
8	quarts	= 1 peck (pk.)
4	pecks	= 1 bushel (bu.)

(A bushel contains 2,150.4 cubic inches.)

Measures of Time

60	seconds (sec.)	= 1 minute (min.)
60	minutes	= 1 hour (hr.)
24	hours	= 1 day.
365	days	= 1 year.

METRIC EQUIVALENTS

1 centimeter (cm.)	= 0.3937 inch.
1 meter (m) = 100 cm.	= 39.37 inches = 1.0936 yds.
1 square centimeter (sq. cm.)	= 0.155 square inches.
1 square meter	= 1.196 square yards.
1 cubic centimeter (c. c.)	= 0.061 cubic inch.
1 cubic meter	= 1.3079 cubic yards.
1 liter	= 1.0567 liquid quarts.
1 kilogram (kilo. or kg.)	= 2.2046 pounds.
1 metric ton (1,000 kilo.)	= 2204.6 pounds.
1 inch	= 2.540 centimeters.
1 yard	= 0.9144 meter.
1 square inch	= 6.452 square centimeters.
1 square yard	= 0.8361 square meter.
1 cubic inch	= 16.387 cubic centimeters.
1 cubic yard	= 0.7646 cubic meter.
1 liquid quart	= 0.9463 liter.
1 pound	= 0.4536 kilogram.
1 short ton (2,000 lbs.)	= 0.9072 metric ton.
1 long ton (2,240 lbs.)	= 1.0160 metric tons.
1 kilo per 100 square meters	= 54.25 sq. yds. per pound.
1 square yard per pound	= 54.25 kilos per 100 sq. m.
1 thread per square inch	= 0.19685 threads per square of 5 mm. side.
1 thread per sq. of 5 mm. side	= 5.08 threads per sq. in.
1 thread per square inch	= 0.23622 threads per square of 6 mm. side.
1 thread per sq. of 6 mm. side	= 4.23334 threads per sq. in.

(NOTE—In the Spanish, Cuban, and Philippine tariffs, cloth constructions are stated in terms of threads per square of 6 millimeters side; in most other countries using metric system in terms of threads per square of 5 mm. side.)